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A DIFFICULT RAILROAD TRANSPORTATION FEAT.

By the English Correspondent of SCIENTIFIC AMERICAN.

WE recently described in the SCIENTIFIC AMERICAN the huge stern frame and brackets for the new Cunard turbine liner which was recently launched on the River Clyde. These castings were carried out at Darlington in Yorkshire, and the transportation of the main section of the stern frame from the Darlington Forge Company's foundries, owing to the abnormal dimensions, presented considerable difficulties on the part of the railroad authorities. The casting was transported by rail as far as Middlesbrough, at which point it was transferred to a steamer which carried it to the shipbuilding berth on the Clyde.

In the casting of this section 69 tons of metal were required, but in the finished condition the section weighed 50 tons. For the carriage of the casting a special freight car was necessary, and owing to the width of the section there was a considerable overhang on each side of the trolley, so that three tracks were required.

Traffic upon the railroad system between Darlington and Middlesbrough had to be completely stopped, so that the tracks might be quite clear. In order that inconvenience might be reduced to the minimum, Sunday was selected for the operation. The casting was securely bedded on the trolley car and balanced at either end, so as to prevent movement set up by traveling,

TRANSPORTING THE HUGE STERN FRAME AND BRACKETS OF THE "LUSITANIA."

VIEW OF THE FRAME, SHOWING THE ENORMOUS OVERHANG.

A DIFFICULT RAILROAD TRANSPORTATION FEAT.

by two heavy steel ingots. In order to be able to cope with any difficulties that might be encountered *en route*, either from the casting shifting on the trolley or obstacles beside the track, two powerful steam cranes carried on cars, one in front and the other behind, accompanied the trolley, so that complete radius over the whole track was instantly available in case of emergency.

The train set out from the foundries at nine o'clock in the morning and reached Middlesbrough six hours later. Owing to the delicacy of the operation the speed of the train had to be limited to three miles per hour throughout the whole distance. At one point the train had to be brought to a stop to allow of a portion of a station, which the overhanging portion of the casting could not pass, to be removed, while similarly semaphore posts had to be temporarily set back, and other obstacles on the track removed. Upon arrival at Middlesbrough the casting was lifted off the trolley and lowered into the hold of the steamer in waiting, which was provided with an extra large hatchway to permit the passage through of the frame. The smaller pairs of brackets, weighing 22½ and 24 tons each respectively, were dispatched per railroad in the usual manner, as they could be stowed upon a car with but little difficulty.

[Continued from SUPPLEMENT No. 1591, page 25490.]

INTERNAL-COMBUSTION MOTORS.*

By DUGALD CLERK, M. Inst. C.E.

THE large gas engines are still in a state of rapid flux as to cycle of operation and details used in carrying out the cycle. It is only necessary to look at Figs. 5, 6, 7, and 8 to see how widely experienced makers vary in their ideas of what is required in large engines. Examples of other engines mostly Continental, applied to large powers, are shown in Figs. 9, 10, 11, 12, and 13. These engines are: the great "Cockerill" engine, which is the largest in dimensions of any yet built with a single cylinder; the latest "Deutz" engine, single cylinder, double acting, of 250 horse-power; the large "Koerting" engine of "Clerk" cycle, built up to 1800 horse-power; and the large "Oechelhäuser" engine of modified two-cycle, somewhat on "Clerk" lines, of 500 horse-power. These drawings are all from engines of the latest types by the various makers. These examples sufficiently prove, if proof be needed, the wide range now covered in this subject. It is only necessary to say a few words as to the mechanical details. In all internal combustion motor construction lift-valves are now quite universal; slide valves have entirely disappeared. In England ignition is accomplished mostly by the hot tube with timing valve for small engines, and by magneto for large engines, while the spark and magneto are used exclusively for motor car engines. The magneto appears destined ultimately to supplant all other modes of ignition. In starting the smaller fixed engines, modifications of the hand pump method are largely in use. For large engines compressed air stored in a reservoir is almost exclusively adopted. As to the number of impulses given to the crank, this is now entirely a matter of arrangement: the difficulties of piston rods and stuffing glands have been overcome by the elaborate system of watering now so common; and, accordingly, engines such as the 500-horse-power "Crossley" (Fig. 5) are very usually arranged to give two impulses per revolution to the same crank, just like the steam engine. As the "Otto" cycle is used, however, two cylinders are required in the gas engine to do the work of one cylinder in the steam engine. In all the very large engines, the multiplication of impulses is very generally adopted. In the "Koerting" engine, two impulses per revolution are given by utilizing the "Clerk" method of charging the cylinder by means of separate pumps driven by a crank at right angles, in advance of the main crank. The large engines are governed generally by either throttling or cutting off the total charge at varying points in the suction stroke. By this method consecutive impulses are maintained throughout the whole range of the load.

So much for mechanical details. It is now desirable to consider the question of heat efficiency, because here will be found the main ground where the physicist and chemist can assist the engineer.

Heat balance sheets showing the results obtained by many well-known engineers from different engines tested between 1882 and 1900 are given in Table I. The particulars given indicate a steadily increasing efficiency throughout that period. In Slaby's first test the heat converted into indicated work was only 16 per cent of the total heat given to the engine, and this has risen to 28 per cent and 31 per cent in 1898 and 1900, as shown by tests of the "National" and "Crossley" engines. Higher efficiencies† than these are claimed, and it may now be accepted that heat efficiencies of 30 per cent—and slightly more—have been really attained by these engines. The table shows another peculiarity in the numbers indicating the heat rejected in the water circulation. This proportion has been steadily diminishing, and it reaches a minimum in the large "Crossley" engine tested by Mr. Humphrey, where the heat loss to the water jacket is only 24.2 per cent of the whole heat supplied. In 1882 and 1884, the tests of Slaby and Thurston show heat rejected in water circulation as 51 and 52 per cent. The Society of Arts trials show a reduction in one case in the "Crossley" engine to 43 per cent and in the "Griffin" engine to 39 per cent when the heat unaccounted for is included. In Humphrey's test of the "Crossley" engine of 1900, as has been said, the heat loss to the water circulation was 24.2 per cent. In Robinson's test of the "National" engine in 1898 the heat loss was 33 per cent. In only one of the recent engines—the large "Cockerill" engine, tested by Prof. Witz in 1900—does the heat loss remain as high as in 1882. An examination of the heat rejected in the exhaust, on the other hand, shows a tendency to increase. Adding conduction and radiation to the heat rejected in the exhaust, Thurston's figures become identical with Slaby's; and this, compared with later figures, shows an increase from 31 per cent to practically 40 per cent, and in Humphrey's experiments to 48 per cent. In only one case, namely, Witz's experiment on the "Cockerill" engine, is this heat loss shown smaller. In these figures then, we find steadily increasing indicated efficiency, steadily diminishing rejection of heat in water circulation and steadily increasing rejection of heat in exhaust gases. From this it is evident that although engineers have succeeded in increasing the amount of heat converted into work and diminishing the heat flow through the sides of the cylinder, they have increased the discharge of heat with the exhaust gases.

To understand the reasons for this, it is necessary to consider briefly the thermo-dynamics of this subject so far as it is at present understood, in order to see whether further knowledge is required to enable the meaning of the relative losses and gains in these engines to be better appreciated. Although the general thermo-dynamics of the internal combustion motor may be considered to be broadly understood, yet physical and chemical knowledge of the properties of air and other gases at high temperatures is as yet insufficient to enable the physicist or engineer to formulate a quantitatively accurate standard engine of comparison; that is, to formulate a conceivable engine in which all heat losses by conduction and radiation are suppressed, and the efficiency of which is the full efficiency of the particular cycle under the assumed conditions, whether perfect or imperfect.

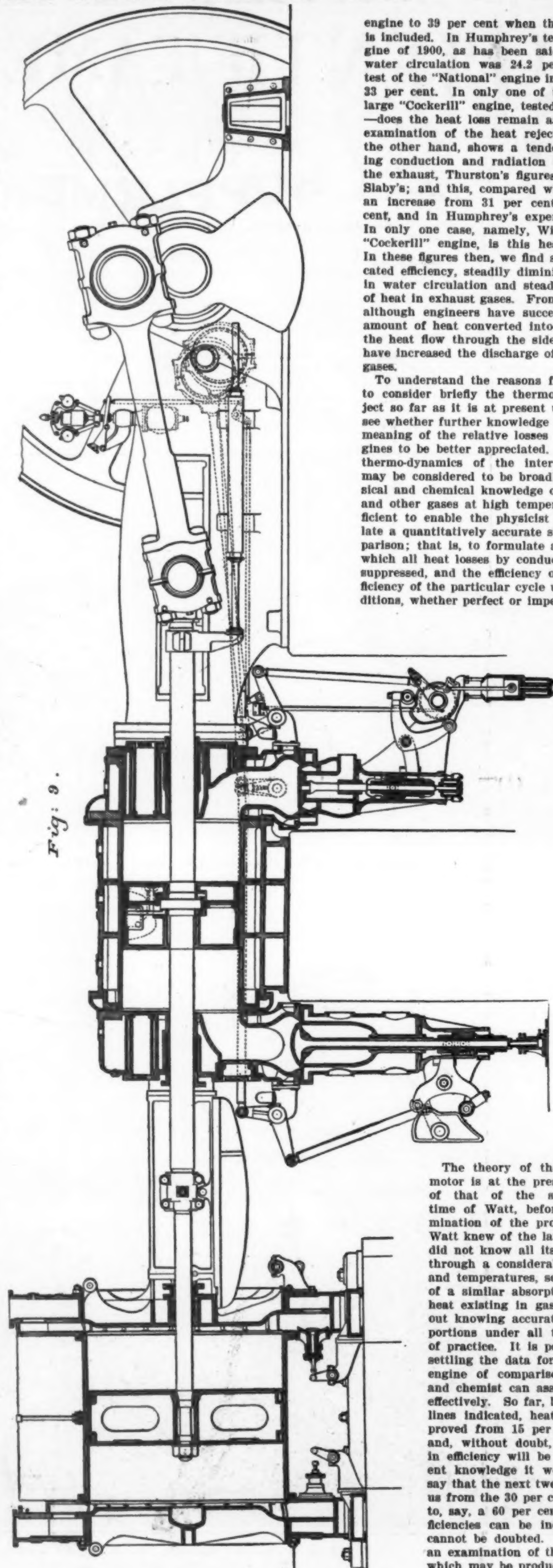


Fig. 9.

1,200-HORSE-POWER COCKERILL GAS ENGINE.

SCALE — Fig. 6 — 10 — 1 Inch = 4 Feet.

The theory of the internal combustion motor is at the present time in the state of that of the steam engine at the time of Watt, before the accurate determination of the properties of steam. As Watt knew of the latent heat of steam but did not know all its properties accurately through a considerable range of pressures and temperatures, so engineers now know of a similar absorption or suppression of heat existing in gaseous explosions, without knowing accurately its causes or proportions under all the various conditions of practice. It is perhaps in this task of settling the data for an accurate standard engine of comparison that the physicist and chemist can assist the engineer most effectively. So far, by following the broad lines indicated, heat efficiencies have improved from 15 per cent to 30 per cent; and, without doubt, further improvement in efficiency will be made, but with present knowledge it would be impossible to say that the next twenty years would carry us from the 30 per cent efficiency of to-day to, say, a 60 per cent efficiency. That efficiencies can be increased much further cannot be doubted. This is evident from an examination of the change in efficiency which may be produced under certain con-

* Being the "James Forrest" Lecture, delivered at the Institution of Civil Engineers. Session 1903-1904. Excerpt Minutes of Proceedings of Institution of Civil Engineers. Vol. clviii. Session 1903-1904. Part iv.

† The "Premier" Company claim 37 per cent, but Mr. Humphrey's experiments do not appear to be sufficiently conclusive to justify the acceptance of this figure.

ditions in an engine operated by pure air. Such a standard was first proposed by me in a paper read before the Institution in 1882. In that paper it was recognized for the first time that a standard most nearly approximating to practical conditions of that day would give constant efficiency for a given compression volume for all maximum temperatures above the temperature of compression. The standard engine of comparison which would correspond most closely with present practice is an air-engine operated between a maximum and a minimum volume as follows:

Adiabatic compression of air from maximum to minimum volume; addition of heat at minimum volume, raising the temperature from the temperature of compression to the maximum temperature; adiabatic expansion to maximum volume, and discharge of heat at maximum volume.

Assuming constant specific heat of air throughout the temperature range, it can be shown that the efficiency is constant for all maximum temperatures; that is, for all heat additions above the temperature of adiabatic compression. If γ for air be taken as 1.408, then

$$E = 1 - \left(\frac{1}{r}\right)^{0.408}$$

where E denotes the efficiency

and $\frac{1}{r} = \frac{\text{minimum volume}}{\text{maximum volume}}$

Efficiencies calculated from this formula for various values of $\frac{1}{r}$ are shown in Table II.:

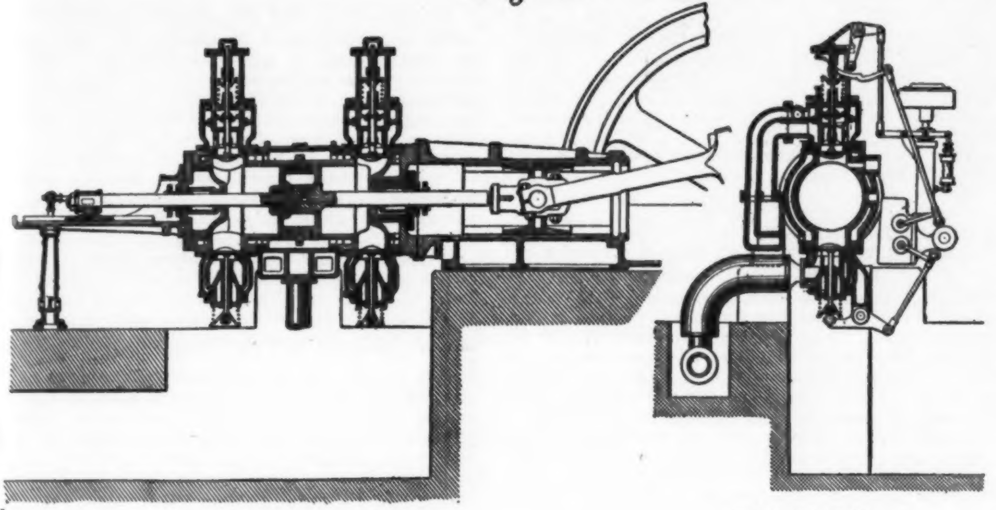
TABLE II.—AIR STANDARD EFFICIENCIES.

$\frac{1}{r}$	E.	$\frac{1}{r}$	E.
		$\frac{1}{7}$	0·55
$\frac{1}{2}$	0·246	$\frac{1}{10}$	0·61
$\frac{1}{3}$	0·36	$\frac{1}{20}$	0·70
$\frac{1}{4}$	0·43	$\frac{1}{100}$	0·85
$\frac{1}{5}$	0·47		

If, then, the compression space be diminished in our supposed engine, it is seen that the heat efficiency steadily increases from 0.246 at ½ to 0.85 at 1/100. No engines have been constructed with a compression space so small as one-hundredth of the total volume. Ordinary practice, however, now goes up to one-seventh, and even one-tenth is exceeded in one or two cases. Within practicable limits, then, if air had been the only working fluid, and its properties were as assumed, then efficiency could be improved within the range of one-half to one-seventh, and compression volume from 0.25 to 0.55. In the older engines, with considerable heat losses, the expansion-curve followed $PV^{1.4}$ very closely; and accordingly these numbers could be considered as the standard efficiencies and deduction be made only for heat flow through the sides of the cylinder, tending to keep up the expansion-line to the adiabatic. It is found, however, that with modern engines having minimum surface exposure and larger dimensions the expansion curve falls more slowly than the apparent adiabatic. In an engine of usual design of large size the extreme appears to be $PV^{1.2}$. Assuming air to be of constant specific heat, this can only mean that heat is being added during the whole expansion stroke to an extent sufficiently great not only to make up for the loss through the sides of the cylinder, but to prevent the whole of the work being done at the expense of the initial energy of the working fluid; that is, heat is added during the expansion stroke. In such a case heat is added to the working fluid, not only at minimum volume, but also during the whole expansion. In this case it will be found that the efficiency is not constant for all heat additions above the temperature of compression; and, as the expansion curve $PV^{1.2}$ may be taken as an extreme case, I have calculated various cases approximating to those met in practice.

The results of these calculations are shown in Table III. The first column gives the efficiencies of the standard engine, as in Table II. Column E_1 shows efficiencies of adiabatic compression of air and expansion $PV^{1.2}$, where the maximum temperature is 1,600 deg. and the suction temperature is 0 deg. C. Column E_2 deals with the same case, maximum temperature 1,600 deg., suction temperature 100 deg. Column E_3 deals with maximum temperature 1,000 deg., and suction temperature 0 deg. Column E_4 deals with maximum temperature 1,000 deg., suction temperature 100 deg. The temperatures 1,600 deg. and 1,000 deg. are taken as the extremes used in gas engines for effective work, and 100 deg. is taken as the suction temperature which is ordinarily attained in most gas engines. It will be observed that the efficiencies fall considerably from the standard efficiencies. The greatest fall takes place with the longest expansion. From these numbers it is evident that an air cycle operating so that heat is added as expansion proceeds, in addition to heat added at constant volume, is less efficient than an engine in which all the heat is added at constant volume. In the extreme example the efficiency becomes reduced to 0.76 of the standard efficiency: it falls from 0.61 to 0.467; that is, the effect of adding heat on the expansion stroke in this particular case,

Fig 10.



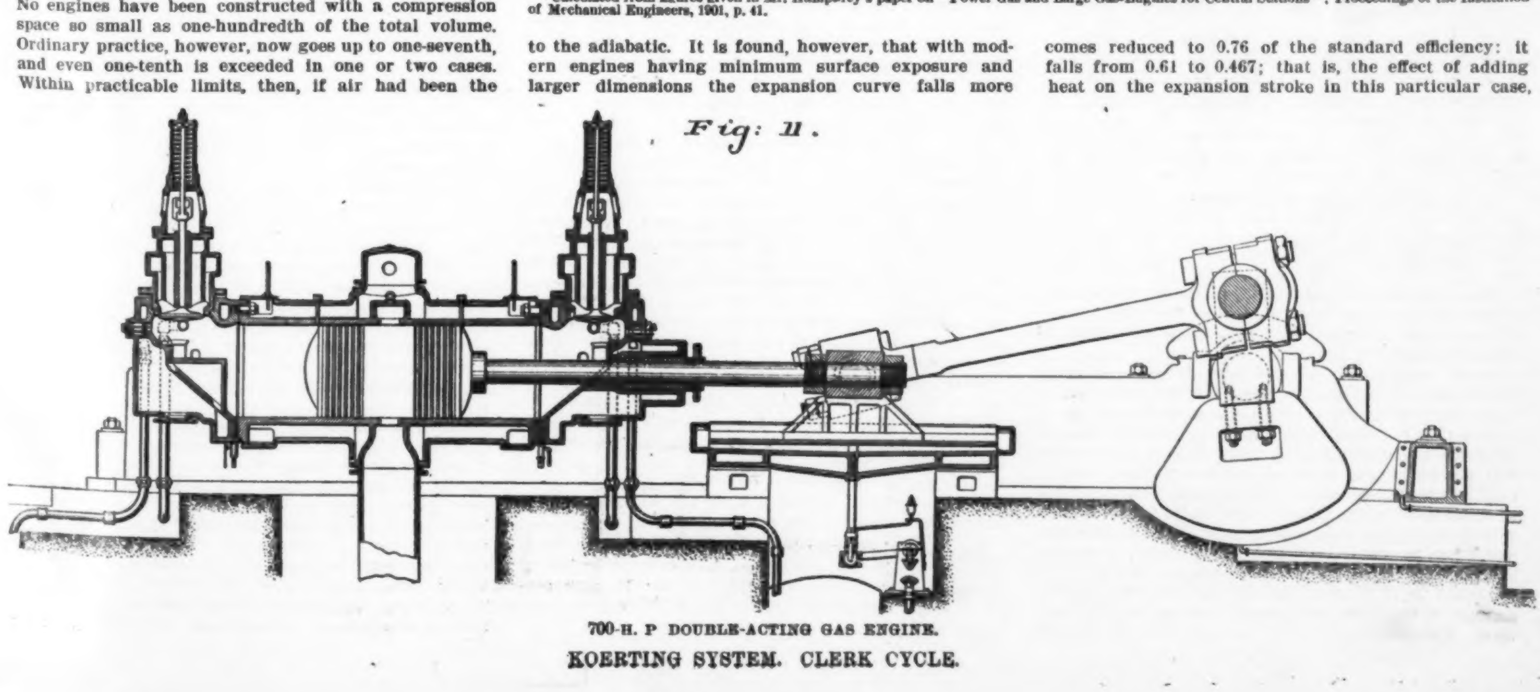
250-HORSE-POWER DEUTZ GAS ENGINE.

TABLE I.—HEAT BALANCE SHEET FROM 1882 TO 1900, WITH OTHER PARTICULARS OF ENGINES.

Name of Experimenter.	Year.	Dimensions of Engine. (Diameter Inches. × Stroke Inches.)	Revolutions per Minute.	Compression.	Expansion.	$\frac{1}{r}$	E Standard Air-Cycle.	Heat Proportions. I.HP.	Rejected in Water Circulation.	Rejected in Exhaust.	Difference Values.	Total.	$\frac{\text{I.HP.}}{\text{E}}$	Heating Value of Gas Taken.	Type of Engine.
Slaby	1882	6·75 × 13·7	160	PV^1	$PV^{1.37}$	$\frac{1}{2·66}$	0·33	0·16	0·51	0·31	0·02 radiation	1·00	0·48	Lower	Deutz.
Thurston	1884	8·5 × 14·0	160	..	..	$\frac{1}{2·66}$	0·33	0·17	0·52	0·155	0·155 conduction and radiation	1·00	0·515	Lower	Crossley.
Society of Arts Trials.	1888	9·5 × 18·0	160	$PV^{1.[illegible]}$	$PV^{1.[illegible]}$	$\frac{1}{3·5}$	0·39	0·221	0·432	0·355	..	1·008	0·565	Lower	Crossley.
Society of Arts Trials.	1888	9·02 × 14·0	200	$PV^{1.[illegible]}$	$PV^{1.[illegible]}$	$\frac{1}{3·2}$	0·37	0·211	0·352	0·398	0·039 unaccounted for, including rejected in blank air charge	1·00	0·575	Lower	Griffin (6-cycle).
Kennedy.	1888	7·5 × 15·0	210	..	$PV^{1.[illegible]}$	$\frac{1}{3}$	0·36	0·209	..	..	..	..	0·585	Lower	Beck (6-cycle).
Capper.	1892	8·5 × 18·0	160	$PV^{1.[illegible]}$	$PV^{1.[illegible]}$	$\frac{1}{3·4}$	0·39	0·228	0·389	0·405	..	1·022	0·58	Lower	Crossley.
Robinson	1898	10·0 × 18·0	170	..	..	$\frac{1}{5·17}$	0·48	0·287	0·33	0·383	..	1·00	0·60	Lower	National.
Humphrey	1900	26·0 × 36·0, 2 Cylinders (A, B)	150 ..	$PV^{1.[illegible]}$ / $PV^{1.[illegible]}$	$PV^{1.[illegible]}$ / $PV^{1.[illegible]}$	$\frac{1}{5}$	0·47	0·278 / 0·31[1]	0·242 in jacket water and exhaust valve	0·48	..	1·00	0·59 / 0·66	Higher / Lower	Crossley. / "
Witz.	1900	51·2 × 55·12	95	..	..	..	0·55	0·28	0·52	0·20	..	1·00	0·51	Higher	Cockerill.

[1] Calculated from figures given in Mr. Humphrey's paper on "Power Gas and Large Gas-Engines for Central Stations"; Proceedings of the Institution of Mechanical Engineers, 1901, p. 41.

Fig: 11.



700-H. P DOUBLE-ACTING GAS ENGINE.

KOERTING SYSTEM. CLERK CYCLE.

by reducing the efficiency from 0.61 to 0.47, makes the high compression pressure due to one-tenth volume of compression no better theoretically than that due to one-fifth when no heat additions are made during the stroke. The loss is less serious where the maximum temperature is 1,600 deg.; and low suction temperatures favor closer approximation to the standard. The cause of the loss in efficiency becomes evident when heat additions during expansion under these circumstances are compared with the heat additions made at constant volume.

The proportion of heat added during expansion to total heat added at constant volume is shown in Table IV., heat added at constant volume being taken as unity.

Taking $\frac{1}{r}$ as one-tenth, the heat added in the 1,600 deg. to 0 deg. C. case is 0.616 of the heat added at constant volume, while in the 1,000 deg. to 100 deg. C. case it is 1.55 times that quantity. As these heat additions are made at lower and lower compressions, it is easy to see that, under these circumstances, lower efficiencies are obtainable. These figures clearly show the desirability of adding all the heat, if possible, at constant volume; that is, of avoiding all heat additions during expansion. If this cannot be done, as little heat as possible should be added during expansion, while the maximum temperature should be kept high, and the suction temperature low.

TABLE III.—AIR STANDARD EFFICIENCIES WITH HEAT ADDED DURING EXPANSION.

$\frac{1}{r}$	Compression $PV^{1.408}$ Expansion $PV^{1.408}$ E.	Compression $PV^{1.408}$ Expansion $PV^{1.2}$			
		E_1 Max. 1,600° C. Suction 0° C.	E_2 Max. 1,600° C. Suction 100° C.	E_3 Max. 1,000° C. Suction 0° C.	E_4 Max. 1,000° C. Suction 100° C.
$\frac{1}{4}$	0·43	0·383	0·380	0·378	0·367
$\frac{1}{5}$	0·47	0·424	0·417	0·415	0·401
$\frac{1}{7}$	0·55	0·476	0·468	0·462	0·440
$\frac{1}{10}$	0·61	0·521	0·507	0·501	0·467

Taking another deviation to imitate what sometimes occurs in practice, the heat addition is assumed to be made so that one portion is added at constant minimum volume, another part is added at constant pressure during the first tenth of the stroke of the piston, and thence the expansion is continued $PV^{1.2}$ to the end of the stroke. Compression is still $PV^{1.408}$. In this case, with maximum temperature 1,600 deg. C. and suction temperature 0 deg. C., E_1 is 0.406; while with the same maximum, but with the suction temperature 100 deg. C., E_2 is 0.358 for $\frac{1}{r} = \frac{1}{10}$. Here there is a great falling off—from 0.61 to 0.406 or 0.358, depending on the suction temperature. These, however, are extreme deviations, which are avoided as much as possible by gas engine designers. It is well known to gas engine constructors that to get the most economical diagram possible the ignition must be fairly sharp and the maximum temperature must come as nearly as possible to the compression end of the stroke. Ignition is always adjusted in actual engines to produce this condition. It is not very common to have expansion curves so flat as $PV^{1.2}$, but expansion $PV^{1.3}$ is very common. Taking compression as $PV^{1.408}$ and $\frac{1}{r} = \frac{1}{5}$, the efficiencies are as follows:

TABLE IV.—HEAT ADDED DURING EXPANSION. HEAT ADDED AT CONSTANT VOLUME 1.

$\frac{1}{r}$	Compression $PV^{1.408}$ Expansion $PV^{1.2}$			
	Max. 1,600° C. Suction 0° C.	Max. 1,600° C. Suction 100° C.	Max. 1,000° C. Suction 0° C.	Max. 1,000° C. Suction 100° C.
$\frac{1}{4}$	0·34	0·388	0·403	0·522
$\frac{1}{5}$	0·40	0·466	0·486	0·660
$\frac{1}{7}$	0·496	0·600	0·640	0·962
$\frac{1}{10}$	0·616	0·788	0·832	1·55

1,600 deg. C. to 0 deg. C.......... $E_5 = 0.45$
1,600 deg. C. to 100 deg. C........ $E_6 = 0.446$

This case corresponds with a more common expansion curve, and here it will be seen that the number 0.45 or 0.446 deviates but little from the standard efficiency, which is 0.47.

In all these cases the expansion is not considered as adiabatic. It has been assumed that the specific heat of air is constant. If, however, it be ultimately proved that the specific heat of air is not constant, the efficiency numbers obtained from similar calculations will not be greatly changed, because variable specific heat assumes a change in the internal energy of the working fluid, which is equivalent in its effects to heat added during an expansion stroke; that is, the heat which has to appear later in keeping up the expansion line above the ordinary adiabatic assumed for air must be stored up in the working fluid in the first instance, because of the increased specific heat at constant volume. Whichever proves to be true, constant specific heat with continued combustion, or varying specific heat with completed combustion, the effect upon efficiency will be very much of the same order as has been here calculated.

Fig. 9. Cockerill gas engine of 1,200 horse-power; double-acting cylinder, 52 inches diameter by 55 inches stroke, driving a blowing cylinder in tandem; watered piston, piston rod and exhaust valves.

Fig. 10. Deutz single-cylinder, double-acting gas engine of 250 horse-power; Otto cycle; cylinder, 21 inches diameter by 27 inches stroke; watered piston and piston rod; governing by reducing lift of charge inlet valve while maintaining constant opening and closing points, thus keeping up consecutive impulses at all loads; forced water circulation through piston, so arranged that if circulation ceases or dangerously diminishes the electric ignition is interrupted and the engine stops; piston and piston rod oiled by forced lubrication.

Fig. 11. Koerting gas engine (Clerk cycle) of 700 horse-power. Single motor cylinder, 28¾ inches diameter by 40½ inches stroke.

(To be continued.)

INTERESTING EXPERIMENTS WITH A CARBURETER WHICH HAS NO FLOAT, NEEDLE VALVE, OR SPRAYING NOZZLE.

DEALING with the action of carbureters, a well known British authority, Mervyn O'Gorman, points out that in most types of carbureters an ever increasing jet of gasolene is drawn in proportion to the increased vacuum as the engine gains speed, and he notes in this connection a triple range of evils: First, that more gasolene is wasted than is necessary; second, that a less quantity of mixture gets into the engine, which affects not only its output, but also its compression, and so influences adversely its efficiency, and, third, that the mixture is incorrect, in that it is too rich and still further reduces the efficiency by overheating the combustion head.

To effect a cure three means are open to the experimentalist—first, to partially destroy or impair the vacuum, as in the plan of the automatic air device; second, to blow more air in at the entrance; and, third, to avoid any throttling in the air inlet, and to supply at each stroke the quantity of gasolene required either in a liquid or vapor form, or even up a wick.

To correct these, Mr. O'Gorman has had made a carbureter which effects the auxiliary air operation by means of a blowing in of the required amount of air, and which totally abandons the use of a float, spray or needle valve and the present type of automatic air valve. The apparatus, in brief, merely consists of a gasolene tank and pipe through which air is blown from the crank case through the medium of a wick.

This experimental carbureter has furnished a result which goes to support the author's claims, and in a diagram illustration the results with three types of carbureters—an ordinary spray, one with the addition of the automatic air valve, and the author's own pressure device—were shown. The results are as follows: The simple spray developed its highest brake horse-power—a margin over eight—at 1,600 revolutions per minute; the second gave its best result at 1,700, when the curve line rose appreciably above the other, while the pressure feed carbureter developed considerably more than 9 horse-power at the much increased speed of 1,900 revolutions per minute—a speed that the other two failed to at all approach.

After detailing the claims of this type of carbureter, the author points out that as gasolene is a liquid and air is a gas, the laws which govern the flow of each are different, and the weight of each drawn in does not depend merely upon keeping the degree of vacuum in the carbureter a constant. More is required than this to comply with the essential condition that the correct quality of the gas be supplied to the motor under the varying conditions of high and low speed.—Bicycle World.

ROLLER BEARINGS FOR STREET CARS.

THE Hanover tramways experiments on a car experimentally equipped with Moffett roller bearings are recounted by H. Schorling in Elekt. Bahnen. The bearings were made by the Norddeutsche Maschinen- u. Armaturenfabrik, of Bremen, who recommended that the bearings should be graphited and then left for six months without any adjustment or lubrication, which recommendation was carried out. Measurements of energy consumption were made on circular ordinary runs extending over several weeks, with three watt-hour meters on the car; readings were taken in the morning, before starting, and in the evening on returning. On the completion of the test, three ordinary cars were fitted with the meters, one after the other, and similar readings taken. As a result the mean energy consumption in watt-hours per kilometer was found to be: Roller bearing car, 486.3; comparison car, ordinary bearings, 598.1; saving 23 per cent. Taking 4.16 Pf. per kilowatt-hour (on the 1904 basis) as the cost of energy the saving is 0.47 Pf. per kilometer (0.097d. per mile). If all the Hanoverian cars were equipped with roller bearings this would mean a saving of 42,300 marks ($8,460) per annum; with dearer power, say 12 Pf. (3 cents), the saving would be 120,744 marks ($30,186); to this has to be added the saving in oil and attendance. After eight months, including the six months without oiling or adjustment, no wear was apparent and the bearings were in good condition.

THE ÆSTHETIC VERSUS THE ECONOMIC VALUE OF NIAGARA FALLS.

THE fate of Niagara Falls under a continuing development of electric power has become a question of national importance. The Outlook for May 19 contains some interesting arguments from both the æsthetic and the industrial points of view.

The æsthetic side is presented by the Outlook in its editorial columns.

Mr. H. W. Buck, electrical engineer of the Niagara Falls Power Company, gives an excellent presentation of the claims of those who believe the industrial value of the Falls is more important than their purely sentimental value. We reprint from both.

NIAGARA FALLS FROM THE ÆSTHETIC STANDPOINT.

The increasing regard in America for æsthetic and sentimental values is something with which law-makers now have to reckon and to which the spirit of commercialism has already been forced to yield. The Outlook heartily believes in the preservation of Niagara Falls as a great scenic feature of the country.

Is the prime object of a man or of a nation to amass all material wealth possible by the cheapest methods inventable? Or have beauty, imagination, poetry, painting, and music, which spring from wealth of the spirit, any demand upon us?

If there were any marked tendency of the American people to neglect material welfare for the pursuit of æsthetic beauty, it might be very well to call public attention to the fact that a hundred millions of dollars run to waste every year over the crest of Niagara Falls. But, as a matter of fact, the tendency has been during the last two centuries quite in the other direction. We do not need to be urged to make money out of our natural resources; we do need to be urged to protect some of our natural resources from the corroding and destructive side of money-making. It is an economic waste for a man to spend his time and money in growing a rose garden in front of his house—cabbages and potatoes pay better; or to put a beautiful Persian rug on his library floor—linoleum can be washed more easily and costs less. But it is not a real waste to collect and possess these objects of beauty. No man has a right to spend more money on things of beauty than he can afford; no village ought to construct and maintain a public park when its school-house is in an unsanitary and tumbledown condition. But, fortunately, this country can very well afford not merely to maintain its parks, its public waterways, and its mountain preserves, but it can afford to add to them.

To our mind, the controversy over Niagara Falls is one of the most important of its kind that has ever demanded public attention in this country, since it is a test case. When the case is thoroughly understood by the people at large, we have every confidence that they will quietly and calmly decide to preserve Niagara Falls from the encroachments of commercial industry, and will devote themselves, if necessary, with scientific skill and patience to the discovery of some other means of supplying the cheap economic power which we trust some day will make electric lighting and street-car travel and useful manufacturing much more general and much less costly than the managers of the Niagara power companies have been able or willing to make them.

NIAGARA FALLS FROM THE ECONOMIC STANDPOINT.

H. W. Buck, Electrical Engineer of the Niagara Falls Power Company.

There are two sides to every question, and the recent outcry from all quarters of the country against the use of Niagara Falls for power purposes may be considered as the expression of opinion only from those who look upon Niagara Falls as a national spectacle, and who consider that its only value to the nation can be represented as such. It is quite natural and proper to regard Niagara Falls from the sentimental and scenic standpoint, for it had been so regarded for many years before it became a national industrial asset of great economic importance. The protest against its use for the development of power has been embittered by the erroneous belief that the capitalists who have developed the power of the Falls have been the only ones to derive benefit from such development.

There is another side to this question, however—the economic one—which has been forced to the front by the developments in science, engineering, and industry during the past ten years, and this phase of the situation cannot be set aside without careful consideration. The development of power at Niagara to-day is not the result of vandalism. It is not a manifestation of the greed of the capitalists for further wealth, nor is it the evidence of the granting by legislatures of monopolistic privileges to the few. Broadly speaking, it is solely the physical expression of the law of supply and demand.

The prairies of the West have been turned to wheat-fields not to enrich the farmer, but because the wheat was needed in the growth of the country. The lumber lands of the continent have been cut and destroyed, not to enrich the lumber dealer, but to satisfy the irresistible demand for wood. So with Niagara Falls, the water is being diverted for power purposes solely because, in the economic and industrial development of the country, the power is needed. This demand, like all commercial demands, is the net result of the actions and desires of all the individuals of the country.

The economic value of Niagara Falls is probably understood by very few of those who protest and petition against its commercial use. The total hydraulic energy of the Falls, if all were developed, would represent about 3,500,000 horse-power. To generate one horse-power continuously for a year by a steam engine requires about thirteen tons of coal. To generate, therefore, continuously 3,500,000 horse-power by steam would require about 50,000,000 tons of coal per year. To generate electric power by steam with the most modern steam plant costs not less than $50 per horse-

power per year, allowing for fixed charges and operating expenses. Niagara power can be generated and sold in large quantities for $15 per horse-power per year, or for $35 per horse-power year less than is possible from the use of coal and the steam engine. From the above it will be seen that if all the hydraulic energy of the Falls were utilized for power purposes, there would result to the country an annual saving of $35 per horse-power for 3,500,000 horse-power, or $122,500,000, and in addition there would be an annual saving in coal consumption of 50,000,000 tons. These figures illustrate what it costs the people of this continent annually to maintain Niagara Falls as a spectacle. They represent the saving to those who would consume the power, and not the profit of those who might own the power developments. This waste involved in prohibiting the development of Niagara power might be likened to a great conflagration in which 50,000,000 tons of coal were annually consumed. Such a conflagration might be one of the most magnificent sights in the world, and people might come from all parts to view it, but the human race would certainly be justified in using every effort to stop the waste by putting out the fire.

The men who have risked their money in the development of the power of the Falls have only obtained a reasonable return on their money and no more. They have not grown rich through their so-called monopolistic privileges, as is generally supposed. Those who derive the real benefit are the owners of manufactories and other industrial enterprises using Niagara power in their processes of manufacture, and through them those who purchase the manufactured products for prices which would not be possible without this cheap power used in their production.

The electro-chemical industry, which might be said to have originated through the development of Niagara power, has already reached enormous proportions, and its future growth depends largely upon cheap electric power. Already we have the carborundum industry and its widely extending applications; the calcium carbide industry and all the acetylene applications dependent upon it; the production of artificial graphite and emery to replace the loss caused by the depletion of the natural deposits; the caustic soda and potash industries; and, by far the most significant, the production of aluminium. All of these industries and many others are dependent for their existence upon the cheap power in large quantities available only at Niagara Falls. Many of the most brilliant minds in the world are at work upon the development of electro-chemical processes which pre-suppose for their operation the availability of Niagara power. Processes for the electric smelting of iron ores not reducible in the blast furnaces are at hand. If these processes cannot be worked by Niagara power, it will result in incalculable loss to the United States and Canada.

The aluminium industry, engaged in the production of this most important metal by an electrolytic process, requires large amounts of cheap electric power. The power item in the production of aluminium is so large a factor that the selling price of the metal must be proportioned on the cost of power used in making it. The applications of aluminium, and consequently the demand for the metal, are increasing with extraordinary rapidity, and unless this growth is to be stopped, cheap power must be available in large quantities. When one considers that the metal aluminium is one of the principal constituents of the earth's crust, the most common metal in our globe, and far more abundant in nature than iron, it becomes evident, as a logical deduction, that it is destined to rank in importance with iron and steel. This metal cannot be reduced from its ores without the use of electric power, and not commercially in large enough quantities without the use of Niagara power.

All of these fundamental industries and the various interests allied with them, together with their thousands of employees, are to have their ultimate destinies determined in the settlement of this Niagara power matter.

The utilization of all of the power of the Falls need not be considered at the present time. Whatever may be the ultimate conditions of power use, it is not now necessary to go further in the discussion than the rights granted to the various power companies now having charters. If all these charters were fully developed, about 1,200,000 horse-power would be available, or about thirty-five per cent of the total energy of the Falls. It is not probable that such diversion of water would appreciably affect the appearance of the flow over the Falls. The eye judges a waterfall largely by two elements—height and width. The diversion of thirty-five per cent of water from the crest of the Falls for power purposes would not influence the appearance of the Falls in either regard. By well-known laws in hydraulics, the actual change taking place would be a diminution in the depth of water at the crest of the Falls and consequently in the thickness of the falling sheet. It is questionable whether such a change in thickness would be sufficiently noticeable materially to impair the grandeur of the general outlook at Niagara. The surroundings and settings of the scene would remain as before, and the general expanse of water would be the same. The Whirlpool Rapids, which many people consider the equal of the Falls in interest and beauty, would remain as they always have been, since the water used for power purposes would be returned to the river above them.

There has been considerable fear expressed that any further diversion of water for power use would dry up the American Falls. It may here be stated that in the course of time the American Falls will become dry, regardless of the development of power. Ten times more water now passes over the Horseshoe Falls than over the American Falls, and the consequent scouring of the Canadian channel now evident will drain off more and more water from the American side. The ultimate salvation of the American Falls will be found in the plan proposed by one of the power companies, and offered to be carried out as a condition of its development. The plan is to dredge a wide channel in the reef which projects out into the middle of the river above the American Falls. This reef has very little water on it, and consequently it acts as a wing-dam, deflecting the water above the rapids over to the Canadian side of Goat Island. It would be a simple problem in hydraulic engineering to dredge a channel in this reef, so that more water could be restored to the American Falls than could possibly flow there now even without any diversion for power.

The economic side of the Niagara problem is a serious one, and it cannot be set aside as secondary to that of the scenic interests. It must be cleared of the prejudices which now discredit it, and its importance to the country at large must be recognized. Niagara Falls is a great continental asset, not only as a scene, but also as a source of power, and any fair adjustment between the two interests must be made upon the basis of a reasonable compromise. The wave of exaggerated sentimentalism now passing should not be allowed to sweep aside all reason, nor be the only thing considered.

PROPERTIES OF GUN-COTTON.

THE manufacture of gun-cotton has been so greatly improved of late years that the gun-cotton of to-day is a superior material to that usually described, even in scientific works. For naval and military purposes the value of gun-cotton cannot be over-estimated. It is a safe, reliable, powerful, portable, and convenient explosive. Wet gun-cotton when properly made and purified can be kept in any climate for any length of time without undergoing spontaneous decomposition. It is doubtful whether dry gun-cotton can be kept indefinitely without undergoing a slight change, but the decomposition can only be detected by the application of delicate stability tests. The effect of sunlight on gun-cotton has often been exaggerated, probably owing to the product under observation being of imperfect manufacture. Properly purified, wet gun-cotton can be exposed to ordinary daylight for very long periods, without undergoing any change. A number of samples* of gun-cotton made at Stowmarket by Lenk's and Abel's processes, between the years 1865 and 1869, and stored in the wet and dry state, exposed to the light, show at the present time no outward signs of decomposition.

Thoroughly purified gun-cotton is neutral to test papers, and is without taste or smell. It preserves the appearance of the cotton from which it is made, being, however, harsher to the touch, and possessing the property of becoming electrified by friction. Plates for electric machines have been constructed with nitrified paper. Ordinary air-dry gun-cotton contains from 1½ to 2 per cent of water, according to the hygrometric state of the atmosphere. The absolute density or specific gravity of gun-cotton is 1.66, its gravimetric density in the pulped state being about 0.3, and after compression 1 to 1.30. The volume of the gases produced by exploding gun-cotton after allowing the steam to condense is about 750 times the volume occupied by the material before explosion. Gun-cotton on explosion gives more gas and a greater quantity of heat than gun-powder, and more gas but a smaller quantity of heat than nitro-glycerine. Dry gun-cotton is ignited by a spark. It explodes when heated to a temperature of about 170 deg. C., and may be detonated by a severe shock. It burns with a yellowish flame, practically without smoke, and leaves no residue. When in the form of pulp and unconfined, it burns about eight times quicker than gunpowder. If, however, the cotton is confined in a strong case, even of wood, it explodes when a light is applied, and the strength of the explosion will depend upon the thickness of the case. In the dry compressed form, unconfined, it burns comparatively slowly, if the quantity is small, but if in bulk the combustion may end in explosion.

Three per cent of water diminishes the sensitiveness of gun-cotton to detonation, 5 per cent renders it incapable of detonation by an ordinary service detonator, and 13 per cent renders it uninflammable. If a disk of wet gun-cotton be put in a fire, it will merely smolder away, as the outer portions in contact with the flames become dried. Experiments made by the British government on a large scale, showed that when a building containing a ton of wet gun-cotton was set fire to, the contents gradually smoldered away, as above described. Wet gun-cotton is not sensitive to shock, so that compressed blocks can be turned or sawn in the same manner as wood, provided that sufficient water is present to insure uninflammability. These properties are most important. They allow the gun-cotton to be stored wet, in which condition it is absolutely safe from any danger of explosion by fire, and it can be re-dried at will for use in small quantities, or left wet for use in large charges.

Gun-cotton is unaffected by water. It dissolves in acetone, acetic ether, and amyl acetate. Cold concentrated sulphuric acid dissolves it on standing; nitric acid is slowly given off, but if heat be applied the action becomes more energetic, and may end in violent decomposition, if the quantities involved are large. A solution of caustic soda or potash in alcohol, decomposes gun-cotton in a few minutes. Aqueous solutions of these alkalis act in the same manner, but require longer time.

Compressed gun-cotton containing up to 20 per cent of water can, however, be detonated by exploding a dry charge or primer of gun-cotton in contact with it, and this fact is taken advantage of in mines, shells and torpedoes, where the great body of gun-cotton is wet, a dry primer is used to detonate the charge.

TABLE I.

Stages of Nitration.	Nitrogen, Per Cent.	Synonyms.	Soluble in	Uses.
Dodeca-nitro-cellulose	14.14	Gun-cotton, best gun-cotton, insoluble gun-cotton, insoluble cotton, insoluble nitro-cellulose, tri-nitro-cellulose.	Acetone, acetic ether, amyl acetate	Naval and military purposes and explosive effects generally.
Endeca-nitro-cellulose	13.47			
Deca-nitro-cellulose	12.75	Soluble gun-cotton, collodion cotton, nitro-cotton, soluble cotton, pyroxyline, di-nitro cellulose, colloxyline.	Ether-alcohol and also the solvents above given for best gun-cotton.	Manufacture of gelatinous blasting explosives, smokeless powder, etc.
Ennea-nitro-cellulose	11.96			
Octo-nitro-cellulose	11.11			Manufacture of celluloid, xylonite, artificial silk, leather and rubber, collodion, collodion films, lacquers and water-proofing solutions.
Hepta-nitro-cellulose	10.18	Low soluble gun-cotton.	Camphorated spirit.	
Hexa-nitro-cellulose	9.15			
Penta-nitro-cellulose	8.02	Friable cotton, mono-nitro-cellulose.	Alcohol.	Not utilized commercially, but exist as impurities in the higher nitrates.
Tetra-nitro-cellulose	6.76			

As the molecular weight of cellulose is not known, the number of theoretically possible stages of nitration must be left undecided. The above table is only intended to show the relative properties of the various nitro-celluloses.

GRAINS USED FOR BREAKFAST FOODS.*

THE grains ordinarily used in the United States for this class of foods are corn, oats, rice, and wheat; less commonly, barley; and in some sections wild rice. In other parts of the world millet, rye, buckwheat, Kafir corn, and other cereals are cooked into porridge, but with us they are too uncommon to warrant extended discussion.

Barley, which grows in almost any latitude, is more commonly eaten in Europe than in the United States, but less now than in former times. Its chief use in this country is for making malt, though pearled barley is frequently put into soups and a few barley breakfast foods are seen. Some of these last, however, are not made from barley alone, but from barley mixed with other grains.

Corn (maize) is a native American cereal, and although used extensively in Southern Europe and parts of the Orient, is still most widely used in this country. Since earliest times corn bread of various sorts, corn mush, and other corn dishes have been popular in the United States, the proportion of corn eaten being perhaps larger in the Southern States than in the North or West. There are many varieties of corn, differing in form, size, and color, but the average chemical composition in all cases is much the same. The germ of corn is relatively large and rich in fat, which tends to become rancid in keeping and is therefore sometimes removed in preparing the more popular meals. The names for the different corn products vary in different parts of the country. In some sections the whole kernels are called hominy and the partially crushed ones samp, while in others exactly the reverse is true. The old-fashioned hulled corn is sometimes called lye hominy. In making this the skin is loosened by steeping the kernels in a weak solution of lye, which gives a peculiar flavor to the product.

Oats are distinctively a cereal of northern regions, and wherever grown are an important porridge staple. In old-fashioned oatmeal much of the husk, which adheres closely to the grain, often remained in the meal. This seems now to have been largely remedied by improved methods of milling, though some tough particles of skin are still left in the finished product. Nevertheless, when thoroughly cooked, oats are a healthful food, the widespread use of which is well justified. The oat breakfast foods keep better than similar products made from wheat and corn.

Rice, as everyone knows, is a staple food in all tropical and sub-tropical regions and is much eaten elsewhere. The unhusked grain is usually called by the East Indian name of paddy. The husk and dark inner skin require special machinery to remove them. In the East new rice is considered inferior to old. All agree that it should not be eaten until three months after harvesting, and many consider it best after it is three years old.

Wheat is the most important breadstuff, and in the United States is also an important breakfast cereal.

* Abstract from Farmers' Bulletin 249, issued by the Department of Agriculture.

The old English dish, frumenty, made by boiling the husked grains with milk and spices, seems to be about the only one in which the grain is used whole. The slightly crushed grains with the bran left on are called cracked wheat or wheat grits. Wheat is also rolled or flaked, and is shredded by a special process. The majority of our wheat breakfast foods seem to contain at least a part of the middlings, farina and gluten preparations being the main exceptions.

Wild rice (*Zizania aquatica*), also called Indian and Canada rice and water oats, is a handsome reed-like water grass native in North America, found as far south as Texas and north into Canada, being especially common in the north-central United States and south-central Canada. The Indians have long used its seeds for food, gathering the crop and parching it to improve the keeping qualities and flavor. Their white neighbors, and especially sportsmen, have more and more followed their example until wild rice has become a well-known food in the regions where it is abundant and has found its way to many clubs and homes and is now seen on the menus of some fashionable hotels, where it is served not only with game but also as a special cereal dish. It gets its name from a very slight resemblance to real rice, the seeds being longer, thinner, and darker in color than the latter, and having a more pronounced flavor. It requires much longer cooking than ordinary rice.

ALCOHOL FROM SAWDUST.

By OUR BERLIN CORRESPONDENT.

A HIGHLY-PROMISING process for utilizing saw-mill refuse has been developed by Prof. Alexander Classen, of the Aix-la-Chapelle Technical High School, in Germany. As the tests made in an experimental plant have given satisfactory results, an industrial plant where alcohol is produced from sawdust on a large scale has recently been erected in this country.

The production of glucose or sugar from cellulose, and its eventual conversion into alcohol, is a process by no means novel. In fact, this was done by Mr. Braconnet as early as 1819, by treating the cellulose with heated sulphuric acid. The sulphuric acid, however, being a liquid, could not be removed from the resulting solution without great difficulty, and only at an expense which rendered the process impracticable for industrial purposes.

Prof. Classen conceived the idea of using, in the place of the liquid sulphuric acid, gaseous sulphurous acid, as this will readily escape on the application of moderate heat, thereby leaving the treated wood practically free from any substances liable to prevent fermentation of the sugar therein. A plant for the manufacture of alcohol from sawdust includes an acid apparatus, in which the necessary solution of the sulphurous acid gas in water is made, and where the gas when escaping from the boiler or digester is reabsorbed in the water, and thereby saved for further utilization; a revolving boiler or digester similar in construction to those used in making chemical pulp; an exhausting battery, consisting of a series of tanks through which water may be passed, and in which the sugar that has been produced in the digester by the sulphurous acid gas may be washed out; neutralizing vats, in which the various acids in the solution are removed or neutralized by the addition of carbonate of lime; and finally, fermenting and still rooms, where the process is completed exactly as carried out in an ordinary distillery.

DIGESTER FOR CONVERTING SAWDUST (CELLULOSE) INTO GLUCOSE (SUGAR).

The sawdust is thoroughly mixed with the sulphurous acid gas and water, thus converting a portion of the cellulose into sugar. This sugar, of which about 85 per cent is fermentable, remains in the sawdust, which is then introduced into the exhaustion tank. Here the sugar is simply washed out.

The digester or boiler in which the wood is first treated consists of a revolving drum of iron, lined with lead to resist the action of the acid, and surrounded with a steam jacket, by means of which it is heated. This drum is nearly filled with sawdust. In the experimental plant one charge consisted of about 400 pounds of the material. To this is added a weight of the acid solution equal to about one-third of that of the sawdust. The steam is turned into the jacket and the drum set to revolving slowly, in order thoroughly to mix the contents. The steam in the outside jacket heats the contents of the digester to a temperature of approximately 295 deg. F. The gas is driven out of the water into the wood, so that it is caused to act directly on the cellulose, converting it into sugar. The pressure inside the digester, due to the expansion of the gas, rises to 100 pounds or more to the square inch. This part of the process lasts three hours.

The sulphurous acid gas and steam are then blown off from the cylinder into absorbing tanks in the acid room, where 75 to 80 per cent of the gas is saved, and may be used again. The digester and the surrounding steam jacket having been blown off, the cover is removed, and the digester is emptied of its contents, which now resemble ground coffee. This material contains the wood fibers and the converted cellulose, now sugar, and various other separated or partially separated products produced by the action of the acid and the heat on the wood. The process is not carried out as far as it is in pulp making, to which it bears some similarity. The object is to convert only as much of the cellulose into sugar as is practicable, and to bring the process to a stop short of a point where the sugar would be destroyed by a reversion.

The digester shown, while a somewhat crude arrangement mechanically, contains all the essential connections and accessories. The gages are used for recording the steam pressure in the jacket and the pressure on the inside of the drum, and the temperature of the same. There are pipes for introducing the gas and the steam, and blow-off pipes for the same.

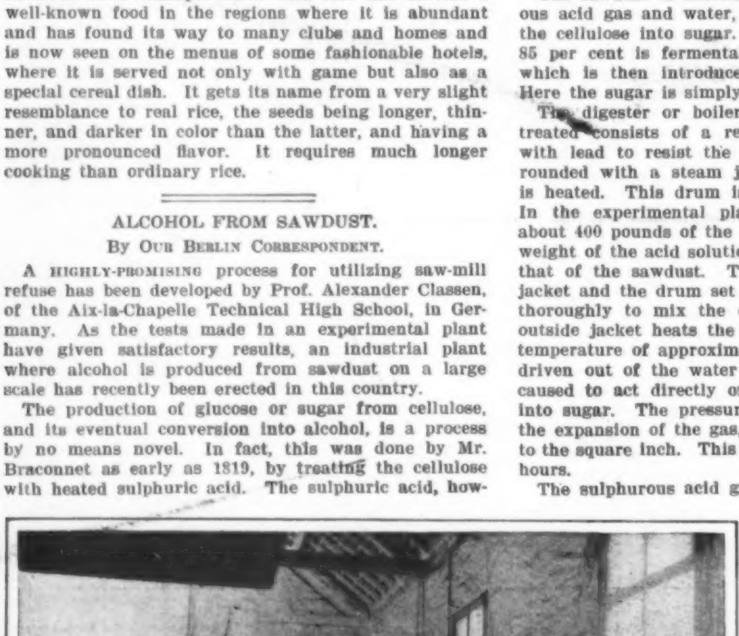
In the experimental plant the exhaustion battery, as the outfit for washing the sugar from the sawdust is called, contains ten tubs or vats capable of holding 36 gallons each. It may be said here that in the commercial plant, it is proposed to handle a long ton of dry sawdust at a time, and the digesters and exhaustion batteries will be proportioned according to this supply of sawdust or other finely-divided wood. Sawdust is considered the best material, but particles of wood up to a quarter of an inch cube, or a quarter of an inch thickness, if in chip shape, appear to be treated as successfully as the former. Each of the tubs in the exhaustion battery in a plant of commercial size would be enlarged to agree with the increased size of the digester. They will be of a different shape from those shown in the illustration, being higher and smaller in diameter in proportion to their height. It is now thought that this should be about nine feet, the diameter five.

These vats are so connected by pipes and valves with each other and with the pump, that the contents of any one tub can be emptied into any other. The principle of this part of the process is to bring the sawdust in contact with the solution already containing sugar, in order to make the solution as strong as possible, and further, to treat the nearly exhausted sawdust with pure water in order to complete the washing thoroughly. The process is continuous, and when the contents of a vat has been treated with ten washings, it is emptied out and refilled with fresh sawdust. Just before emptying, its charge receives fresh water, and after refilling, receives the strong sugar solution.

The result of this process is a solution which contains 450 to 500 pounds of sugar from a long ton of dry sawdust. This sugar is of two kinds, pentose, which is non-fermentable, and the other, amounting to 70 to 80 per cent, capable of alcoholic fermentation when treated with yeast. The solution from the exhaustion battery is pumped into a receiving tank, where it is neutralized with carbonated lime. This is necessary to prevent the acids, either the remains of the sulphurous acid, or certain acids derived from the wood itself, from killing the yeast which is later added for the purpose of fermentation.

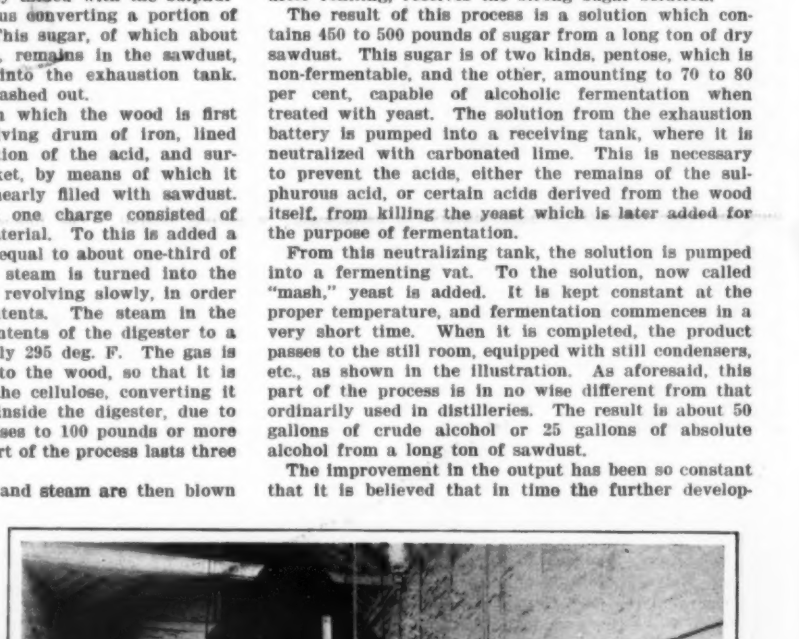
From this neutralizing tank, the solution is pumped into a fermenting vat. To the solution, now called "mash," yeast is added. It is kept constant at the proper temperature, and fermentation commences in a very short time. When it is completed, the product passes to the still room, equipped with still condensers, etc., as shown in the illustration. As aforesaid, this part of the process is in no wise different from that ordinarily used in distilleries. The result is about 50 gallons of crude alcohol or 25 gallons of absolute alcohol from a long ton of sawdust.

The improvement in the output has been so constant that it is believed that in time the further development of the system will enable the manufacturer to obtain 30 gallons, and perhaps more, from a ton of sawdust; but the results obtained so far are quite sufficient to secure the entire approval of scientists and of practical men who are familiar with the manufacture and marketing of grain alcohol. Comparing the original cost of sawdust with that of grain, and the output of alcohol from the former with that from the



The stills and apparatus for preparing sulphurous acid are seen at the right.

GENERAL VIEW OF THE AIX-LA-CHAPELLE PLANT.



At the right: Exhauster for extracting sugar formed in digester. At the left: Alcohol stills.

THE AIX-LA-CHAPELLE EXPERIMENTAL PLANT.

PRODUCTION OF ALCOHOL FROM SAWDUST.

latter, it seems that the new process is destined in time entirely to supersede the older one.

One of the most important features of the process is the utilization of the sawdust after leaving the exhaustion battery. While passing through the various stages of the process it contracts in volume from 25 to 30 per cent, while volume for volume its fuel value is apparently unchanged. As a matter of fact, apart from the cellulose which is removed, no other component having a fuel value has been taken out. If it is desired to use the sawdust as a fuel, it can accordingly be turned back to the mill and burned under the boilers after treatment, thus retaining the original intention. The residue, however, retains unchanged and practically undiminished in quantity such components as make it available for dry distillation. The treatment by heat and acid has left it dead and without apparent elasticity. It can consequently be pressed into briquettes without the use of a binder, and this in itself is an exceedingly valuable property.

LIQUID VERSUS COAL FUEL.

By W. N. BEST.

IN order to compare the practical values of oil and coal as fuel, it is merely necessary to inspect two plants, each of which uses one of these fuels exclusively. In a steel manufactory employing coal for heating purposes we find in the blacksmith's shop great quantities of smoke and gases from the forges and furnaces, as well as incumbering bins which contain the coal. For a certain part of the time the workmen are constantly waiting for the iron to be heated in the forges, and the steam hammer is idle for the same reason. At last a heated shaft is brought out and is hammered into form. But it is noticeable that the metal seems hard and does not respond to blows as it should. The reason for this is the unequal heating due to the coal or coke which gives an abrasive heat with the interior at a lower temperature than the exterior of the metal. After the shaft is hammered for a time, it is returned to the forge and time is again lost in going through the usual process of banking the fire, coaling, blowing, etc. In using coal for welding, we find that this fuel usually causes corrosion between the two pieces of metal, and that consequently, the welds are often faulty. Thus, a weld is apparently perfect in many cases, while, as a matter of fact, the exterior portions alone are welded, while the interior shows decided evidences of corrosion.

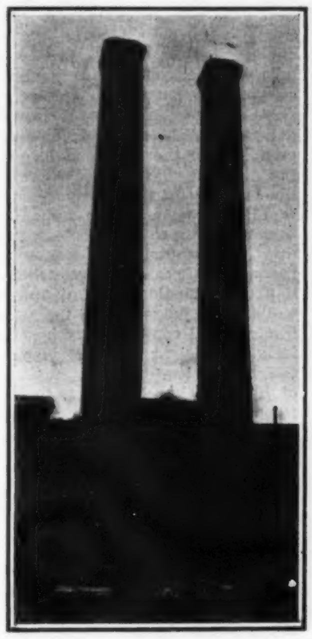
In furnaces used in making bolts, smoke is again prominently in evidence. The output is also limited and frequently the furnace is unable to heat sufficient iron for more than fifty per cent of the capacity of the bolt and rivet machines. The iron, too, is usually covered with scale. In welding new ends upon boiler flues the same difficulties are encountered in using coal for heating as with ordinary welds. The usual number which can be welded per hour is sixteen, and each of these must be carefully tested for evidences of corrosion before being put into the locomotive.

In the scrap iron furnaces the same difficulties are encountered, and a fireman is constantly employed in supplying the furnace with coal and removing the clinkers. Many axles from the furnace are found useless because of imperfect welds. The iron, too, absorbs a certain portion of the carbon from the coal.

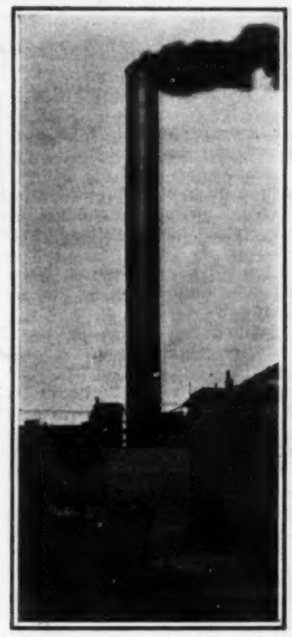
In the boiler room the heat from the coal fires is usually intense, nor can this be decreased by employing bituminous coal, as the city ordinances forbid its use. The coal is buckwheat mixed with bituminous and gives rise to quantities of dust and dirt. Great piles of coal lie upon the floor of the room, and a constant procession of firemen from the coal bins to the boilers is necessary to keep up the supply of fuel. An elaborate system for the removal of ashes, too, is necessary. One of the accompanying illustrations shows a bituminous coal-burning plant with quantities of black smoke arising from the stack. A second photograph illustrates the interior of the boiler room with its encumbering piles of coal ready to be fired.

In a similar plant in which liquid fuel is used exclusively we find the conditions quite different. The elimination of smoke and gases is complete, and consequently everything is far cleaner and brighter in appearance. In the blacksmith's shop there is no waiting for metal to heat, notwithstanding that the capacity of the machinery is exactly the same as in the other plan. The metal is heated quite uniformly throughout, as it appears that oil fuel is much more penetrating in heat effect than coal or coke. There is no damaging effect upon the metal; in fact, it appears that the latter is much more homogeneous than when heated with coal fuel. The burner spreads a fan-shaped flame over the entire width of the furnace, giving a much more equable heating. The welds are excellent, exteriorly and interiorly, as it appears that there is no corrosion with oil fuel. The furnaces for the bolt and rivet machines are heated by liquid fuel, and the machines are running at full capacity, giving a perfect output. The flue-welding furnace has the same advantages when heated with oil fuel; near it is a flue-welding machine turning out welded flues at the rate of sixty in sixty minutes. The flue-welds are considered so perfect that it is not necessary to test them before placing the tubes in the locomotive.

An axle furnace equipped with a modern hydrocarbon burner usually involves different principles than a coal furnace, and it is of different form, with a new type of arch. The monoxide combines with the necessary oxygen to change it to a dioxide before reaching the charging space of the furnace. There is no bridge wall, yet the radiation is perfect. It is astonishing to find that there is no chimney upon any of the furnaces, as the combustion is so perfect that all the heat units can be utilized within the furnace. The burner, too, is practically automatic and requires very little attention. It is claimed that in using the oil furnace there are fifty per cent less flaws than in using other fuels. It has been proved that it is cheaper to use liquid fuel than that supplied by a gas-producer, because of the elimination of the cost of labor and of the handling of the coal, and also by reason of the increased output. For rivet heating in boiler shops or similar institutions, liquid fuel is far more convenient than other fuel and gives the highest possible efficiency. It is said that rivets heated in oil furnaces show greater tensile strength and increased homogeneity over those not so treated.



CHIMNEYS OF OIL-BURNING PLANT.



CHIMNEY OF FACTORY USING COAL.

The cleanliness and roominess of a boiler department in which liquid fuel is used are in remarkable contrast to the drt and crowded appearance of a coal-burning boiler room. A battery of sixteen oil-burning burners requires but two firemen and one water-tender. The temperature also is decidedly lower. Everything can be kept scrupulously clean and usually is in that condition. Certain of the boilers use crude oil, some use residuum oil (fuel oil), while others burn tar. But one burner is used to a boiler and on examining the stack we find no smoke being emitted therefrom. If the firebox is examined, the combustion will be found to be perfect. In using fuel oil the first cost of the installation sometimes appears excessive, yet when all the subsequent factors are considered it is preferable to using coal with its additional cost of handling the fuel and ashes, the employment of extra firemen and the poorer results obtained than with oil. With liquid fuel it is possible to maintain the boiler pressure almost exactly at the desired point, the liquid fuel being more sensitive and prompt to respond than coal.

In an oil-burning locomotive there is no smoke, no disagreeable odor from the consumed gases, and there are absolutely no cinders. In the tender the coal space is taken up by an iron tank which contains the liquid fuel. There is but one burner under the boiler, and the supply is regulated by a simple little quadrant and handle. There are no sparks and the fire losses along the line of the road are cut to a minimum. No sparks from the ashpan can set fire to the ties or bridges, and it is easy to maintain the pressure 5 pounds below the popping point. As the burner requires very little attention, the fireman has an opportunity to watch the signals and thereby double the protection to the lives of the passengers behind the engine. No cars are required to handle ashes and the care of the locomotive is greatly facilitated because there are no fires to clean.

Crude oil, like coal, varies in calorific value. The

BOILER ROOM USING LIQUID FUEL.

BOILER ROOM IN WHICH COAL IS BURNED.

OIL VERSUS COAL AS FUEL.

following are the calorific values of various fuels, by means of which they may be compared.

California crude oil varies from 18,462 to 20,680 B.T.U.'s per pound, the average weight of which is 7.6 pounds per gallon.

The Beaumont Texas oil averages 19,060 B.T.U.'s per pound, and weighs about 7½ pounds per gallon. Forty-two gallons of crude oil, United States measure, equals one barrel.

Some Russia oils contain on an average 22,027 B.T.U.'s per pound.

Tar from coke ovens contains 16,263 B.T.U.'s per pound.

Tar from oil water averages 16,979 B.T.U.'s per pound, and varies in weight from 9 pounds to 10.29 pounds per gallon.

Fuel oil (or the residuum from oil refineries) varies from 18,350 to 19,342 B.T.U.'s per pound and averages 7.2 pounds per gallon in weight. Fifty gallons of fuel oil is considered one barrel.

Gasoline contains 14,200 B.T.U.'s per pound, weight 5.9 pounds per gallon. The evaporation of this fuel is very great unless confined.

Coke varies from 12,645 to 13,500 B.T.U.'s per pound.

Coal gas varies in its calorific value from 552 to 567 B. T. U.'s per cubic foot.

Calorific value of wood compared with liquid fuel is as follows: 4,500 pounds of hickory equals 738 pounds crude oil; 3,250 pounds of beech or oak equals 610 pounds crude oil; 2,350 pounds of poplar, chestnut, or elm equals 483 pounds crude oil.

Bituminous coal contains from 11,963 to 15,622 B.T.U.'s per pound; a general average of coal in the United States can be placed at 13,180 B.T.U.'s per pound.

[Concluded from SUPPLEMENT No. 1591, page 25495.]

INFLUENCE OF LIGHT AND HEAT ON GERMINATION.—II.*

By CLEVELAND ABBE.

AFTER this preliminary historical survey, Pauchon communicates the results of his own experiments as to the influence of light on germination on the following twenty-two species of plants:

Cruciferæ:	Leguminoseæ:
Brassica napus.	Arachis hypogæa.
Iberis amara.	Dolichos lablab.
Lepidium sativum.	Rubiaceæ:
Sinapis alba.	Coffea arabica var. Rio.
Raphanus sativus.	Spilanthes fusea.
Ranunculaceæ:	Helianthus annuus.
Delphinium Consolida.	Carthamus tinctorius.
Nigella sativa.	Malvaceæ:
Cucurbitaceæ:	Hibiscus esculentus.
Cucurbita melo var. melon vert.	Polygonaceæ:
	Fagopyrum esculentum.
Papaveraceæ:	Linaceæ:
Papaver somniferum.	Linum usitatissimum.
Euphorbiaceæ:	Bignoniaceæ or Pedaliaceæ:
Ricinus communis.	Sesamum orientale.
Gramineæ:	Liliaceæ:
Zea mays.	Pancratium maritimum.

After deducting doubtful results or failures Pauchon gives the following conclusions (see p. 131 of his work above quoted):

(1) In 22 experiments germination occurred first in the light; in 26 experiments it occurred first in the dark.

(2) Five times we obtained duplicate results favorable to the light for the same species of plants (*Arachis, Zea mays, Dolichos, Sinapis*, and *Linum*). Eight times these duplicate results were favorable to specimens kept in the dark (*Helianthus, Delphinium, Pancratium, Ricinus*, and *Papaver*). In one case (*Linum*) two results were obtained favoring light and two favoring darkness.

(3) Among the 22 species of plants used in the experiments, 14 gave mixed results equally favorable whether placed in the light or the dark.

(4) Among the eight other varieties only one gave negative results (*Coffea*); three gave results favorable to light (*Cucurbita, Spilanthes*, and *Carthamus*); four gave results favorable to darkness (*Delphinium, Pancratium, Lepidium*, and *Nigella*).

It appeared to Pauchon impossible to draw any conclusion whatever from these facts. Should we be astonished at this? The problem is certainly much more complex than appears at first sight. There is every reason to suppose, for example, that the action of light is not the same under all the conditions of temperature which obtained during these experiments. Here again, however, we are confronted by the unknown; because, in order to draw from these researches the consequences which might flow from them it would be necessary to know precisely the thermic conditions favorable to the germination of each species. Unfortunately this is a very important gap to be still filled up, as the work accomplished in this direction gives only approximate results limited to a very small number of different kinds of seeds. On the other hand, looking to facts of another order, mentioned further on in this work, we think that we may be allowed to suppose that the influence of light can only be favorable to germination when it acts at temperatures below that which is most favorable to germination. A considerable number of observations already cited would seem to be in accord with this view of the subject. But unfortunately the many contradictions that we observed in our results do not allow us to accept this opinion as based upon a solid foundation.

Pauchon then goes on as follows:

"Another reason, however, induces me to admit, only with many reserves, the results of experiments whose critical epoch is the visible development of the embryo. A method based on this special observation does not appear to me capable of furnishing a really scientific basis for the determination of the question before us. The process of germination is not, in reality, as simple a phenomenon as the greater number of botanists, perhaps too easily, take for granted. Its complexity is even so great that one can not judge of the actual development of the germ of the plant and of the degree of its physiological activity by the external characters observable by the eye, such as the bursting of the spermoderm and the more or less rapid protrusion of the radicle. I do not hesitate to say, according to observations frequently repeated, that this is an empirical process and entirely deceptive in the particular case that we are dealing with. Although it may be capable of furnishing valuable results when we wish to judge of the influence of some one of the fundamental conditions of germination, it becomes utterly insufficient when it is a question of observing the more delicate and fugitive influences, such as that of light. I have, in fact, in the course of chemical researches, given in the next chapter, demonstrated that for the same age of apparent development the absorption of oxygen by the seeds in the process of germination varies to a large extent with the temperature, and has no relation to the external growth of the embryo. It is, however, not surprising that the development of the embryo continues in the interior of the seed for a much longer time in one seed than in another of identical appearance; the unknown and variable relation between the reserved nutrition and the rudimentary vegetable is probably the explanation of these hitherto unexplained peculiarities.

"Although the researches given in this chapter do not give any positive result on the subject of my work, I have preserved them and publish them here in order to explain to observers the defects of an experimental process to which, in the future, they would themselves have been tempted to resort; this moreover, seems to me the more useful in that up to this time this danger does not seem to have struck the attention of botanists. On the other hand, my observations contain some new data relative to the temperatures favorable for the germination of certain exotic seeds.

"In consequence of the conclusions to which we have thus been led, it would be useless to study the action of the different portions of the solar spectrum on the apparent progress of germination. How, in fact, can we suppose, in view of the contradictory results already obtained for the condition of light and of darkness—that is to say, for the most extreme conditions—that the employment of the same method can reveal a difference of action for the various portions of the spectrum?

"Is it then necessary, after this first fruitless attempt, to give up the solution of the problem, or shall we seek it by another and better method? It is this latter alternative that I have adopted in that I have taken for the basis of a new series of observations the variations of a physiological process that, in an almost mathematical manner, measures the germinal activity of the vegetable embryo, namely, the respiration."

After giving the details of his experiments on respiration of plants, Pauchon draws the following conclusions (p. 166):

"The laws brought prominently forward by the results of these experiments are:

"(1) Light exercises a constant and more or less marked accelerating influence upon the absorption of oxygen by seeds in the process of germination. All the experiments made in a strong light have not, however, the same value in demonstrating this fact. But if we have doubts about the precision of the results furnished by experiments in which germination did not invariably take place (and we believe that we have shown by some preparatory experiments that these results have at least a relative value), this certainly is not the case with experiments Nos. 2 and 8, in which all the seeds did germinate. Thus experiment No. 2 showed in favor of light a result as to the oxygen absorbed twice as great as that given by the seeds placed in the dark. In the same way in experiment No. 8 this superiority reaches to one-third of the quantity of oxygen absorbed by the seeds placed in the dark. Finally, the other experiments, and particularly those classed under Nos. 3, 6, and 7, further confirm the generality of this action of light, which we will, besides, find again in a second series of experiments reported hereafter, several of which have shown unanimity of germination in both cases.

"(2) There exists a relation between the degree of light and the quantity of oxygen absorbed. Thus, in a diffuse light this accelerating influence shows itself in a most marked manner when the sky is very clear, and the solar radiation reaches us in its greatest intensity. Such was the case in experiments Nos. 2 and 8. Whenever the sky is cloudy this action is more and more weakened and ceases altogether when the sun is completely veiled, as in stormy weather, so that there is a semi-obscurity.

"However, in all the experiments where the final result has been favorable to the action of light I have convinced myself that a cloudy sky for twelve hours always showed itself in the amount of the absorption of oxygen in such a manner that the examination of these figures, noted day by day, would almost serve to show the state of the atmosphere during the day which preceded the observation. A very conclusive instance of this action is given us by experiment No. 4 of the second series, in which the state of the sky being carefully observed it showed very marked changes.

"(3) The accelerating influence exercised upon seeds exposed to the action of light during the day did not stop at night; it continued to act in the dark with an equal, sometimes even with a greater intensity. I will cite as examples experiments Nos. 3, 4, 6, 7, and 8, when observations made twice a day, morning and evening, allowed of examining the fact I state. How can we explain this persistent action of light? One hypothesis only can be admitted. A portion of the action of the light absorbed by the grain during the day is stored up by it and used by it at night to accelerate its respiration. The proof of this is that the differences of elevation [or quantities of absorbed oxygen] shown in the morning by the instruments for seeds kept in the dark are always below those shown by the instruments and plants in the light. The influence of the light, then, continues for a certain time, at least several hours, even after the light itself has ceased to act; on the other hand, however, this action is not exerted immediately. There is one other phenomenon that we have demonstrated by our experiments. Suppose the sky to be very clear; the differences in favor of light are only apparent after two or three days and become much more marked toward the end of the experiment; that is to say, in proportion as the daily action of sunlight is more and more frequently repeated.

"(4) I should also call attention to still another peculiarity, viz., that the differences in the quantities of oxygen absorbed in the dark and in the light were generally much greater at the beginning of these researches than in the later experiments, and particularly in those of the second series. The temperature appears to me to be the only element that varied in these experiments. There must therefore be a more intense respiratory action exercised by light at low temperatures, and this influence would become weakened at high temperatures. This fact would be in entire agreement with the demands of physiology. It is easy of comprehension that a scarcity of heat should be counterbalanced by the action of light, which furnishes for the reaction of the respiratory organs the force that they could not obtain from an insufficient temperature. On the contrary, when the heat is intense the intervention of the light is no longer necessary, the first cause being sufficient to excite the process of germination in the protoplasm of the seeds.

"(5) This action of light seems to differ a little according as it acts upon seeds containing albumen or those without albumen. In the case of the albuminous seeds of the castor-oil plant the advantage was much more apparent in favor of those exposed to the light, which advantage appeared to me much less decided for the seeds without albumen, such as the haricot bean. Nevertheless, as the experiments were not invariable in their results, the cause of the variations observed can also be accounted for by attributing them to certain differences in the atmospheric conditions.

"(6) The more considerable absorption of oxygen by seeds under the influence of light explains the fact that asparagine (the medium for the conveyance of the reserved albuminous substances in the germination of leguminous plants) only disappears in plants exposed to the light and continues present in those raised in the dark. The comparative researches of Pfeffer (1872) upon the chemical composition of asparagine and other substances showed that asparagine is poorer in carbon and in hydrogen and richer in oxygen than legumine and other albuminoids. The transformation of legumine into asparagine is accompanied by the absorption of a certain quantity of oxygen. On the other hand, it is effected only by the influence of light; the reason being that light increases the quantity of oxygen absorbed, and therefore exerts only an indirect influence on this change, as had already been surmised even when we were not acquainted with the reasons.

"(7) Other new and important conclusions become apparent from these experiments and those which follow, and although they have no direct connection with the subject of my work I think it will be well to designate them briefly.

"The quantity of oxygen absorbed in a certain space of time by a seed in process of germination varies very considerably according to the temperature; it increases with it, as has been already proved in treating of the respiration of plants in the dark. The general results of my experiments, and particularly of Nos. 9 and 10, leave no doubt of this fact. We can therefore easily understand what errors have been committed by those experimentalists who have given calculations of this absorption of oxygen by certain seeds without taking into consideration the conditions as to temperature. Their figures have no value whatever, particularly in view of the fact stated by me several times already, viz., that the quantity of oxygen absorbed by a seed is not at all in proportion to its apparent development, but, on the contrary, undergoes considerable variation, depending upon the influence of the external agents affecting the phenomenon. According to my observations, this quantity may vary as two to one, or even more, in two plants of identically the same weight, but placed in different thermic conditions from the commencement of their germination to the emerging of the rootlet. From this point of view, then, the plant acts like a complete organism, its respiratory action being accelerated or retarded always, however, within physiological limits, like those of an animal under the influence of certain exterior changes."

Having thus shown that germinating seeds absorb more oxygen in the light than in darkness, Pauchon

* Abstracted from Bulletin 86 of the United States Department of Agriculture.

conducted some experiments to determine the ratio between the oxygen and the carbonic acid, and draws the following conclusions:

"Experiments Nos. 3 and 4 have a real value for the solution of the problem brought forward in this part of my work. As to the partial results given by experiments Nos. 1, 2, and 5, their accuracy cannot be doubted; therefore I shall make use of them as confirmatory documents. I must repeat that the numbers used for the proportions of carbonic acid are a little smaller than they should be in reality, in consequence of peculiarities inherent to the method and already explained; but as this diminution, which is almost insignificant, is equally present in all the quantities, the result is that the numerical quantities are always comparable, although the ratio may be diminished in an inappreciable degree. Finally, I may add that the conclusions which follow are only applicable to plants under precisely the same conditions as those under which my experiments were conducted.

"(1) I note, first, that experiments Nos. 3 and 4 confirm in the most precise manner the general fact of the accelerating influence exercised by light upon the absorption of oxygen; but, these experiments having been carried out at a higher mean temperature, the differences in the quantity of oxygen absorbed in the light and in the dark are generally less than in the first series of experiments.

"(2) As to the exact relative quantities of carbonic acid exhaled, it was a little more for the castor-oil plant in the dark than in the light, the contrary being the case for the scarlet runner bean. From this we might conclude that the influence of light produces doubly favorable effects upon the germination of the castor-oil plant, (*a*) by increasing the absorption of oxygen, and (*b*) by diminishing the exhalation of carbonic acid, thereby increasing the gain of oxygen by reducing the expenditure of carbon and oxygen. (It must not be forgotten, in this explanation, that one volume of carbonic acid gas contains one volume of oxygen.) From this particular point of view the scarlet runner bean seems to be less favored than the castor-oil plant, although the excess of the quantity of carbonic acid exhaled by either placed in the light is nearly insignificant when compared with that exhaled by the same species kept in the dark.

"(3) In the dark the ratio $\frac{CO_2}{O}$ as determined by four experiments divided equally between the seed of the castor-oil plant and those of the haricot bean, was at least a third more in favor of the latter than the ratio obtained for the castor-oil plant. The length of the experiment appears to me to have exercised a certain influence upon this ratio. Thus, for the castor-oil plant the figures reached 0.586 in experiment No. 2, which lasted about four days, and 0.771 in experiment No. 3, which lasted five days. The same was the case with the haricot bean; the result was 1.138 for experiment No. 4, which terminated during the fourth day, and 1.034 for experiment No. 5, which was prolonged until the sixth day. In a word, the prolongation of the experiment tends to render the ratio $\frac{CO_2}{O}$ equal to unity. With the duration of the experiment this ratio rises in those cases where it is below 1, but diminishes where it is above 1, until the seed is consumed and the period of vegetation, properly so called, arrives, during which latter time the final limit may be reached when the quantities of oxygen absorbed and the carbonic acid exhaled balance perfectly.

"(4) In the light the ratio $\frac{CO_2}{O}$ is about a third more for the haricot bean than for the castor-oil plant. But the sum obtained in experiment No. 2 was very much below that stated in experiment No. 5. The duration of this experiment and its prolongation until the approach of the vegetating period appears to me to account for this difference. This hypothesis is supported by the results of experiments Nos. 1 and 4, the first having lasted six days and the other less than four.

"(5) By comparing the ratio $\frac{CO_2}{O}$ for similar experiments made in the light and in the dark, we see that there is always a difference of a quarter of the value of this ratio in favor of the dark; or, in other words, a seed placed in the dark always exhales more carbonic acid for the same quantity of oxygen absorbed than a seed kept in the light, even although sometimes, as we showed in experiment No. 3, the absolute quantity of carbonic acid exhaled is less in the light than it is in the dark. Finally, while in the light the carbonic acid released is always much less in quantity than the oxygen absorbed, the contrary may be the case in the dark, where the absolute amount of carbonic acid may even exceed the absolute quantity of oxygen, as is proved in experiment No. 4, where the absorption of oxygen 37.36 corresponds to an exhalation of 42.54 of carbonic acid.

"(6) In order to consider the influence exerted upon the ratio $\frac{CO_2}{O}$ by the nature of the grain itself under different conditions as to light and darkness, it is only necessary to consult the conclusions which precede, and note the marked differences that distinguish the albuminous and oily seed of the castor oil from the non-albuminous and starchy haricot bean.

"(7) The facts which precede complete the explanation already given of the transformation of legumin into asparagin under the influence of light. In general, the absorption of a greater quantity of oxygen only assures the formation of asparagin in so far as the amount of carbonic acid exhaled is less than the amount of oxygen absorbed; since asparagin is poorer in carbonic acid and richer in oxygen than legumin, all the conditions favorable to that formation are to be found demonstrated in the results of experiment No. 4, with seeds exposed to the light. It is very probable that a portion of the oxygen which had disappeared and that was not found as carbonic acid was absorbed by the albuminoids when forming asparagin, and we know from other sources that this substance seems to form in the majority of seeds during the process of germination.

"This absorption of oxygen during the period of germination is still greater in the castor-oil seed than in that of the bean. The oily seed, therefore, seems to be more favored by nature from a physiological point of view.

"(8) We might be tempted to compare the ratio $\frac{CO_2}{O}$, obtained during the time of germination, with the same ratio during the period of vegetation. But the sum for the vegetating epoch has only been precisely fixed in the dark, which for green plants is entirely an abnormal state. As, on the other hand, it is impossible to gage exactly the quantity of oxygen absorbed, and the amount of carbonic acid exhaled by a plant placed in the light and under natural conditions, it will easily be understood why we refrain from making any comparison until we are in possession of all the data necessary to carry out the calculation.

"(9) The facts which precede convince me that the seeds of uncultivated plants germinating in the light are, all other conditions being equal, better distributed than the seeds of cultivated plants; that they possess a greater germinating power, an advantage which increases their chances for ulterior development."

PEARLS.

By Dr. L. G. Seurat.

The pearls of greatest and most ancient renown are obtained from a mollusk of the genus *Margaritifera*, incorrectly known as the pearl "oyster." There are several species, which are distributed through the hot regions of the globe. The oldest pearl fisheries are those of the Red Sea, the Persian Gulf, and Ceylon.

Pearls obtained from fresh-water mussels were esteemed by the Romans but have little value to-day. The pearl oyster furnishes nearly all the pearls which come to the European market. At present the most important pearl fisheries are those of Ceylon and the Persian Gulf. The small meleagrine (*Margaritifera vulgaris*) of those localities is, however, found also in the Red Sea, the Mediterranean (since the opening of the Suez canal), Torres Strait, and New Caledonia. Of less importance are the fisheries of the Dutch Indies, Torres Strait, western Australia, the Tuamotu and Gambier islands, the Gulf of California, the Bay of Panama, and Margarita Island, off the coast of Venezuela. Pearls, usually of no commercial value, are found occasionally in edible oysters.

The pearl oyster is found at depths of from 15 to 130 feet, attached to an empty shell or a branch of coral by a bundle of very strong, dark-green filaments called the byssus. In old specimens the byssus contains more than 500 threads. The mollusks are gathered by divers, with or without diving suits. The pearl divers of Ceylon and the Persian Gulf accelerate their descent by means of a large stone attached to a rope, in a loop of which the foot is placed. The Arabs of the Persian gulf employ the same method and also stop their ears with wax and compress their nostrils with a clamp made of horn.

The natives of the Tuamotu Islands, a French Pacific colony, may justly claim to be regarded as the best divers in the world. They descend to depths of more than 100 feet without the aid of weights. Arriving at the fishing ground early in the morning in pirogues or sloops, they anchor and examine the sea bottom with the water telescope. The use of this instrument, which is merely a square wooden tube with one end closed with a pane of glass, has been learned from the Europeans. Formerly the surface of the water was smoothed by applying cocoanut oil. When the diver has thus discovered the pearl oysters he breathes deeply for several minutes. Then with his lungs filled, he dives feet foremost, but at the depth of about 30 feet he inverts himself by a sudden movement of his arms and legs and thence descends, head downward, to the bottom, snatches his prey and ascends. On reaching his boat he at once opens the oysters by cutting the adductor muscle and searches them for pearls.

The pearls are usually found in closed pouches in the dorsal part of the body. Their presence is not betrayed by any external indication except that they are rarely found in very young oysters or within very clean shells. The oysters of certain beds yield more pearls than those of other beds.

Besides these fine pearls (as they are known in commerce) which are found unattached in the body of the oyster, other pearls are found adhering to the inside of the shell. The latter are called chicots, and have comparatively little value.

Fine pearls are graded according to form, size, color, and luster. Perfectly spherical white pearls are the most valuable. The value of a pearl, other things being equal, is proportional to the square of its weight in grains. Luster is the character of the surface which produces the soft but brilliant luminosity and play of color of fine pearls, an effect due to the exceedingly thin concentric layers of which they are composed. A piece of mother-of-pearl cut to the form of a pearl has no luster.

Pearls perfectly matched in size, shape, and color command a far higher price than that of the same pearls sold separately. Irregularly shaped pearls, or baroques, are sold by weight.

Pearls are liable to deterioration from various causes. The acid secretions of the skin, foul gases, salt water, and soap injure them, and sudden changes of temperature may cause them to crack or even to burst. In the course of time the pearl becomes dull, or old, to use the technical term. When it has completely lost its luster it is said to be dead. Attempts have been made to restore the luster of dead pearls by various methods, none of which produces very satisfactory results. The most curious of these methods consists in feeding the pearls to fowls, and killing these after the superficial layers of the pearls have been removed in the process of digestion.

The structure of pearls, like that of shells, is studied by examining polished thin sections by transmitted polarized light. Many pearls exhibit a stratification similar to that of shells but with the order of the strata reversed. The center is formed of a yellowish-brown substance closely resembling the periostracum or outer layer of the shell. This is surrounded by a layer of prisms of carbonate of lime resembling the middle layer of the shell. The outer or nacreous layer of the pearl is composed of a number of independent concentric strata which can be peeled off one by one like the coatings of an onion. The jeweler sometimes takes advantage of this peculiarity to obtain a pearl of fine luster by removing the outermost opaque strata of a dark and dull specimen.

This typical structure, however, is subject to great variation. Some pearls have only one of the three layers and the middle prismatic layer is wanting in the very finest pearls, which are composed of exceedingly thin nacreous strata immediately surrounding the nucleus.

Chemically, pearls are composed of carbonate of lime, water, and a large amount of organic matter. To the last constituent they owe the hardness which enables genuine pearls to be easily distinguished from imitations. The density varies from 2.650 to 2.686. Pearls dissolve so very slowly in vinegar that the story of Cleopatra drinking a cup of vinegar in which she had dissolved a pearl must be relegated to the domain of fable.

The problem of the origin of fine pearls has been, and is to this day, a much discussed subject. Many writers have confounded them with shell pearls or chicots, which are formed in a very different way. Chicots are lumps of mother-of-pearl secreted by the epithelium which covers the mantle of the mollusk and which also secretes the innermost layer of the shell to which these pearls are attached. Their production is due to an irritation of the mantle by any cause, such as the introduction of a grain of sand or other foreign body between the mantle and the shell. Occasionally this foreign body is a fine pearl which has gone astray, and for this reason pearl merchants often pay good prices for chicots or shell pearls in the hope of finding fine pearls inside of them.

Linnæus and some other naturalists attempted to provoke the secretion of pearls by perforating the shells of pearl-bearing mussels, introducing pellets of limestone, mother-of-pearl and other substances and covering the holes with bits of mother-of-pearl, fastened with cement. In time the pellets became covered with a deposit of mother-of-pearl and, usually, attached to the shell, but no very good pearls have ever been produced by this method.

Bouchon-Brandely repeated these experiments, with better success, on the pearl oyster of Tuamotu. More recently Boutan has endeavored to obtain pearls from the *Haliotis* (sea ear or abalone) in this manner, and has produced in a few instances a luster suggesting that of fine pearls.

All these experiments have only theoretical value and are of interest merely because they exhibit in detail the mechanism of the secretion of mother-of-pearl.

Some writers of the sixteenth and seventeenth centuries regarded pearls as the eggs of the mollusk. As late as 1826 a modification of this theory was put forth by Home, who thought that pearls were formed about eggs that had failed to be expelled by the oviduct. Other authors have regarded pearls as calcareous concretions analogous to the calcospherites which are formed in the bodies of men and animals. Rondelet (1554) considered them to be concretions due to disease, like the urinary and other calculi of mammals. According to Diguet, who has studied the question in the pearl oyster of the Gulf of California, the development of a pearl comprises three stages. In the first stage there appears a sack filled with a translucent, serous liquid, the effusion of which is due, probably, to irritation caused by a parasite. In the second stage the liquid gradually thickens and assumes the appearance of jelly. Then it becomes converted into conchyoline and the mass divides into concentric layers separated by interstices. The third stage is the petrifaction or calcification of the pearl by the filling of these interstices with a crystallized calcareous deposit.

The theory which is most generally admitted at present is that pearls are the result of a secretion induced by the presence of parasites. This theory was abandoned by Filippi, who announced, in 1852, that the pearls of the fresh-water mussels in the royal park of Racconigi, near Turin, were caused by a parasitic worm or "fluke," a species of *Distoma* (closely allied to the parasite which causes "rot" in sheep). In 1856 Küch-

enmeister announced that the pearls of the mussels of Saxon rivers had as their nuclei small ticks or mites.

The parasitic theory has received much support from the researches of recent years. Jameson, in 1902, showed that the formation of pearls in the edible mussel (*Mytilus edulis*) is due to irritation caused by the *Distoma*. The investigations of Herdman and Hornell in Ceylon, and my own studies in the Gambier Islands point to a parasitic origin of the pearl of the pearl oyster also. According to the two English naturalists the nucleus of the fine pearl of *Margaritifera vulgaris* is the embryo of a worm of the genus *Tetrarhynchus*.

In the pearl oyster of the Gambier Islands (*M. margaritifera Cumingi*) I found that the formation of pearls is due to irritation caused by the embryo of a worm of the genus *Tylocephalum*, characterized by a single suctional organ, without hooks. The life cycle of this parasite is completed, not in the oyster but in the rectum of the eagle-ray (*Aetobatis narinari*), a fish that breaks the shell of the pearl oyster and devours its flesh. These fishes abound especially over the richest pearl beds. They are driven away or killed by the native pearl-fishers but it is evident that it would be advantageous to protect them.

The problem of the origin of pearls appears, therefore, to be very near solution, and the possibility of producing fine pearls at will seems not very distant. The lagoons of the Tuamotu Islands are admirably adapted to experiments of this nature, the success of which would greatly benefit this French Polynesian colony.—Translated for the Scientific American Supplement from La Science au XXme Siècle.

DETAILS ENTERING INTO THE CALCULATION AND CONSTRUCTION OF WELLMAN'S POLAR AIRSHIP.

The airship in which Walter Wellman expects to start from Norway for the North Pole in the near future was designed and constructed by Louis Godard, the well-known builder of aeronautical apparatus. In ordering this airship Wellman kept constantly in view the purpose for which it was intended, namely, polar exploration, and he aimed at the obtaining of practical results rather than at high speed. The purposes for which the balloon is intended made it necessary to reject at once any project for a dirigible with a maximum speed, such as is used in France for military purposes, on account of the difficulties met with in a balloon of large cubic contents, in which the length is five or six times the greatest diameter. These difficulties relative to the manageability of an airship, to its inflation, and to the construction of its framework, have rendered preferable to the dirigible of normal length a rather shorter balloon, of a shape which will cause the resistance to advance to be as small as possible. This shape is shown in the heavy lines in Fig. 1. The bow of the balloon is parabolic in shape, while the stern is in the form of an ellipsoid. The greatest diameter is thus situated about two-fifths of the distance from the stern.

VOLUME AND SURFACE.

The dimensions of the balloon are greatest diameter, 16 meters (52.49 feet), and greatest length 50 meters (164.04 feet). Its length is therefore 3.125 times its diameter. The total surface is 9,160 square meters (98,561.6 square feet) and the cubic capacity 6,350 cubic meters (224,218.5 cubic feet).

DETERMINATION OF RESISTANCES TO ADVANCE OF THE BALLOON.

In order to determine as exactly as possible the resistances to the advance of the airship, a comparison was made with the coefficients of different types of cigar-shaped dirigibles, the resistances of which had previously been effectually measured. The two types used for comparison were "La France" and the "Lebaudy." The following method is the most rational one, being based on the known different value of the coefficients obtained in experience with dirigibles.

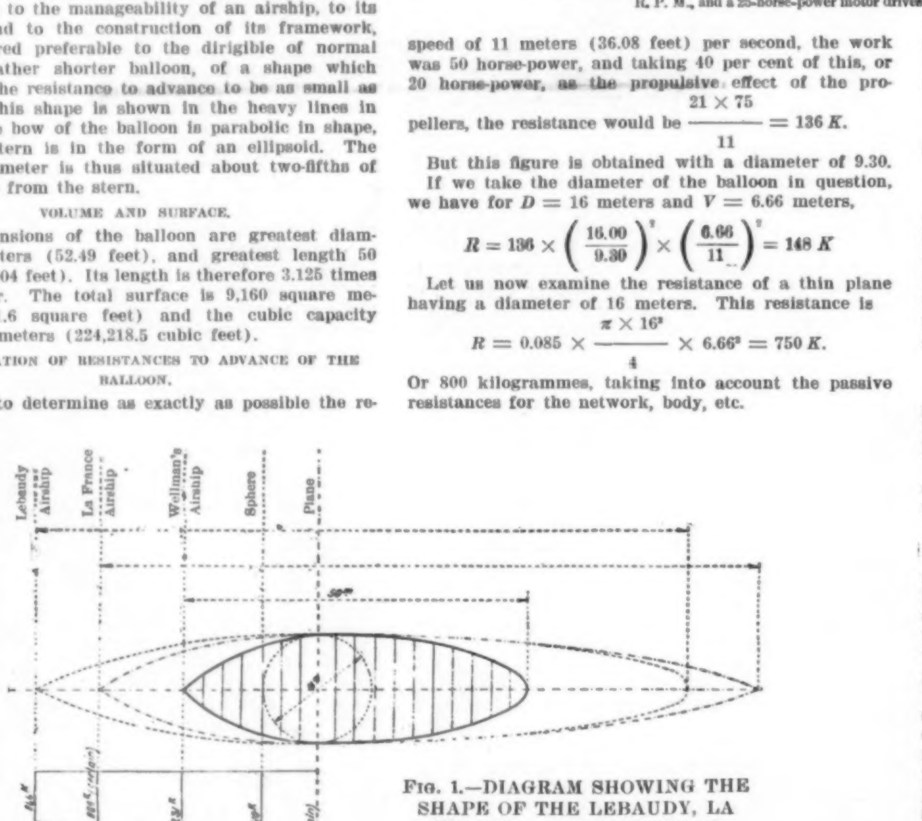


Fig. 1.—DIAGRAM SHOWING THE SHAPE OF THE LEBAUDY, LA FRANCE, AND WELLMAN AIRSHIPS.

This diagram shows the Head Resistance, known and calculated, of these different-shaped airships in comparison with a plane and a sphere.

Taking the coefficient obtained with "La France" balloon, which is 0.01685 $d^2 v^2$, for a similar type in which the diameter, D, is 16 meters and the required speed, V, equals 6.66 meters per second (or 24 kilometers—14.91 miles—to the hour) the resistance will be:

$$R = 0.01685 \times 16^2 \times 6.66^2 = 192\ K.$$

In comparing the "Lebaudy" type, in which, with a speed of 11 meters (36.08 feet) per second, the work was 50 horse-power, and taking 40 per cent of this, or 20 horse-power, as the propulsive effect of the propellers, the resistance would be $\frac{21 \times 75}{11} = 136\ K.$

But this figure is obtained with a diameter of 9.30.

If we take the diameter of the balloon in question, we have for $D = 16$ meters and $V = 6.66$ meters,

$$R = 136 \times \left(\frac{16.00}{9.30}\right)^2 \times \left(\frac{6.66}{11}\right)^2 = 148\ K$$

Let us now examine the resistance of a thin plane having a diameter of 16 meters. This resistance is

$$R = 0.085 \times \frac{\pi \times 16^2}{4} \times 6.66^2 = 750\ K.$$

Or 800 kilogrammes, taking into account the passive resistances for the network, body, etc.

For a sphere the resistance is 0.35 of a plane of the same diameter. We have, therefore, $R = 750 \times 0.35 =$ 262 kilogrammes, or 300 kilogrammes (660 pounds) with the body and the network.

The above figures have made it possible to trace curves showing the variation in resistance according to the type of the balloon, all of the balloons having the same diameter of 16 meters. This curve gives about 235 kilogrammes (517 pounds) for the present type of balloon, which is traced in the diagram in full lines. (See Fig. 1.) From it we can deduce the coefficient of resistance, which will be equal to $5.20\ V^2$.

Making R equal to 235, the work to be performed is 235×6.66 meters $= 1{,}565$ kilogramme-meters (31.127 horse-power). If we admit the final screw efficiency of 40 per cent, the power of the motor required will be $\frac{1{,}565}{0.40} = 3{,}910\ K$ or $\frac{3{,}910}{75} = 52$ horse-power.

This, then, is the horse-power required to produce a speed of 24 kilometers (14.91 miles) an hour.

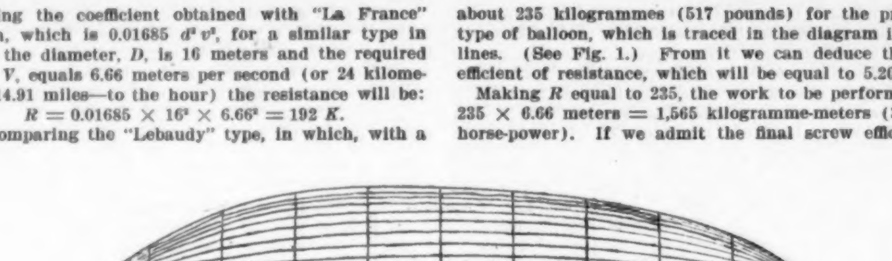


Fig. 2.—GENERAL APPEARANCE OF THE WELLMAN AIRSHIP.

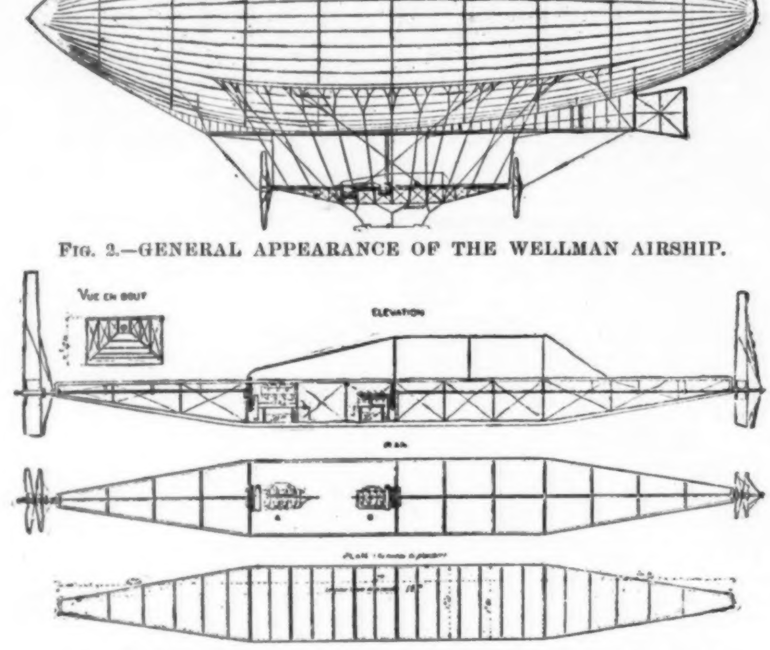


Fig. 3.—SIDE ELEVATION AND PLAN VIEW OF THE BODY FRAMEWORK OR "NACELLE."

The total length is 16 meters (52.49 feet), the length of each tapered end being 4.5 meters (14.76 feet.) The width is 1.8 meters (5.9 feet). A 60-horse-power gasoline motor drives the 18-foot forward propeller at a speed of 200 R. P. M., and a 25-horse-power motor drives the 15-foot rear propeller at 280 R. P. M.

STABILITY.

An attempt has been made to obtain stability by attention to different details, particularly by making the balloon as short as possible. This is also provided with vertical and horizontal planes, which will be placed at its rear part as far back as the rudder, and which will tend to give it a longitudinal and lateral stability. The rudder has been designed of sufficient size to be efficacious when the balloon is under way.

ASCENSIONAL FORCE.

Figuring on a minimum ascensional force of 1,110 grammes per cubic meter, we obtain for the total lifting power of the balloon $F = 6{,}350 \times 1{,}110 = 7{,}048$ kilogrammes (15,505.6 pounds).

The point of application of the resultant of the ascensional forces is located in the middle of the longitudinal axis.

COMPOSITION OF THE FABRIC OF THE BALLOON.

As the material of which the balloon is constructed must resist different pressures according to whether it is located in the ends or at the center, it has been specially selected for the place it will occupy in the envelope. The material used in the central part will weigh 505 grammes per square meter (0.103 pound per square inch) and that used at the ends only 455 (0.093 pound), the difference being in the weight of the silk alone. Starting from the inside, the balloon is constructed as follows: Silk, 85 grammes to the square meter (0.0174 pound per square inch); pure Para rubber, 105 grammes to the square meter (0.0215 pound per square inch); cotton, 105 grammes to the square meter; rubber, 65 grammes to the square meter (0.0215 pound per square inch); cotton, 100 grammes to the square meter (0.02048 pound per square inch); rubber, 45 grammes to the square meter (0.009 pound per square inch). The resistance of the fabric is from 2,400 to 2,500 kilogrammes (5,280 to 5,500 pounds).

NOTES ON THE FABRIC.

In general, very thin sheet rubber, such as is used in the construction of balloons, disintegrates rapidly under the action of light and cold. This is why, in the composition of rubber materials for balloons, the exterior fabric receives a coating of chrome yellow (chromate of lead). In the present case, however, on account of the short time which the balloon will be in service, and on account of many other considerations, the exterior fabric will be covered with a thin layer of rubber for the following reasons: First, to obtain an exterior surface that will be more supple; second, to avoid the penetration of dampness into the exterior fabric, and the consequent weighting down of the balloon by water vapor or rain; third, the exterior layer

of rubber will protect the two interior layers, which join together the three layers of fabric.

WEIGHT OF THE DIFFERENT PARTS OF THE BALLOON.

Balloon, strengthening bands (silk and cotton), five valves, ballonette: 1,425 kilogrammes (3,135 pounds); body part, 330 kilogrammes (726 pounds); suspension wires, 120 kilogrammes (264 pounds); governor and frame, 50 kilogrammes (110 pounds); motor, 50 horse-power complete, 275 kilogrammes (605 pounds); propeller, its shafts and gears, 95 kilogrammes (209 pounds); blower and its motor, 50 kilogrammes (110 pounds); stopping apparatus and anchors, 100 kilogrammes (220 pounds); tanks and radiators, 25 kilogrammes (55 pounds); second motor of 25 horse-power, with propeller and shaft, 200 kilogrammes (440 pounds); front propeller and its extra shaft, 95 kilogrammes (209 pounds); other parts, 35 kilogrammes (77 pounds); total, 2,800 kilogrammes (6,160 pounds).

The other parts include provisions, various instruments, gasoline, oil, water, four automobile sleds, one light steel boat, and one guide rope.

CALCULATIONS OF THE PROPELLER.

In order to determine the proper diameter, pitch, speed, and efficiency of the propellers, the same method was followed as was used in determining the resistance to advance of the balloon, that is to say, use was made of the results obtained with the propellers on "La France" and "Lebaudy" airships.

Front propeller: Taking at first, for comparison, the propellers of the "Lebaudy," these have the following characteristics: Diameter, $d = 2.44$; surface of the blades, $s = 0.57$; for a speed of 11 meters (36.08 feet) per second and 1,000 R. P. M., the speed at the extremity of the propeller blades was found to be

$$\frac{\pi \times 2.44 \times 1{,}000}{60''} = 127.70\ m., \text{ or}$$

$\frac{27}{11} = 11.6$ times the speed of propulsion. A Lebaudy propeller giving $\frac{136\,k}{2} = 68\,k$ of traction, the traction of such a type of propeller responds to $K \times 2.44^2 \times 11.00^2 = 68\,K$, whence $K = 0.094$, but with a blade area equal to $0.096\,d^2$.

If we take the blade area equal to $0.175\,d^2$ the coefficient K will become $\frac{0.094 \times 0.175}{0.096} = 0.170$.

We will, therefore, have for this new type of blade $q = 0.170\,d^2v^2$.

As we must have $q = 235\,k$ and $v = 6.66\,m$, we can write $d = \sqrt{\frac{235}{0.170 \times 6.66^2}} = 5.60\ m.$

The surface of the blades will therefore be $S = 0.175 \times 5.60^2 = 5\ m.q \times 200$.

In analyzing the calculations obtained from the incidences of the angle of the blades, the angle of incidence was deduced as follows: $f\ (i) = 1.46\ \text{Sin.}\ i$, which corresponds sensibly to the results obtained with "La France" propeller when it was mounted on a stationary point. The diameter of the large propeller is 5.70 meters (18.696 feet). The number of turns per minute will be $\frac{6.66 \times 11.60}{\pi \times 5.70} \times 60 = 260$. As for the blade area, the surface will be about 5.700 $m.q.$ The tractive power will absorb almost all the force produced by the motor.

A guide rope of extremely pliable steel rope about 300 meters in length will remain constantly in contact with the ice.

The diameter and speed of rotation of the rear propeller were obtained in the same way and using the same calculations. In view of the fact that the diameter of this propeller was limited to 4.5 meters (14¾ feet), it absorbs 1,875 kilogrammes, or 25 H. P., and will drive the airship at a speed of 17 kilometers (10.55 miles) an hour. The number of R. P. M. is 285 and the area of the blades is 3.5 square meters (37.67 square feet).

THE METHOD OF EXPLORATION.

The idea of the explorer is to leave Spitzbergen with a favorable wind—a wind from the south if possible, since this is the most propitious, and since it blows generally from 6 to 40 hours—and to profit as much as possible from this favorable wind to augment the speed. With the motors and propellers working, he can still hold to his course by means of the rudders, even if the direction of the wind changes and does not remain so good.

Under the atmospheric conditions found in June, July, and August, which consist, in the environs of the pole and Spitzbergen, of almost constant clouds, at the slight height of 1,200 to 1,500 feet, with a temperature around the freezing point, and the humidity almost constant (only 10 to 15 hours of sun per month), Mr. Wellman has adopted the plan of exploration at a slight height with the aid of a smooth guide rope. If contrary winds blow, this guide rope will drag over the ice and retard the drift backward, the motors not being run under these conditions.

This new dirigible can nevertheless maintain a speed of about 15 miles an hour with its 50-horse-power motor driving the forward propeller. The second, or reserve, motor of 25 horse-power drives a smaller screw located at the rear of the body. This will drive the airship at a reduced speed, or it can be run in connection with the larger motor in order to obtain a speed of 18 to 20 miles an hour.

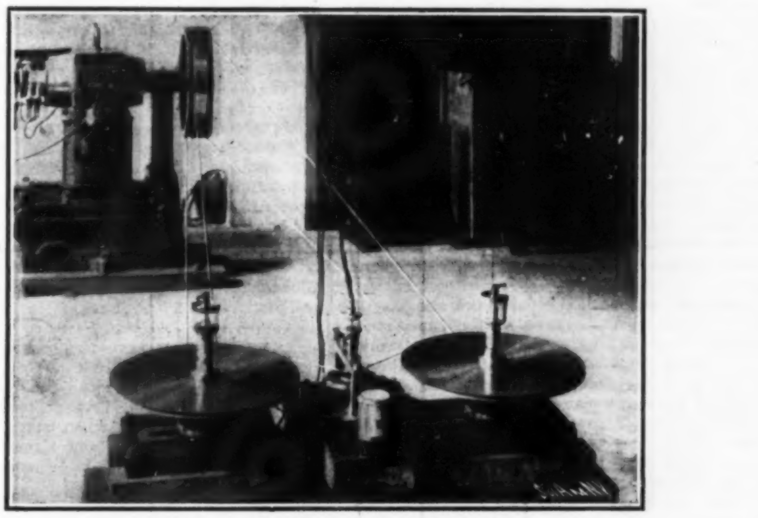
A 120,000-PERIOD ALTERNATOR.*

By EMILE GUARINI.

MR. W. DUDDELL has recently described a very interesting alternator generating current at a frequency as high as 120,000 periods, and he stated that he has described this machine not with a view of suggesting it as the best, or even as a satisfactory design, but rather to indicate some of the difficulties which are encountered in attempting to construct an alternator for high frequencies. This alternator was made for some experiments on the resistance of the electric arc. As the experiments progressed, and it was found that with each increase of frequency the solid arc behaved more and more like an ordinary resistance, the alternator was altered until finally the very high frequency of 120,000 periods per second was attained. The machine served its purpose and allowed the research for which it was designed to be completed, though there are, according to Mr. Duddell, several very obvious improvements which would greatly increase its output and utility. Firstly, the greater part of the difficulties were encountered with the belt-drive and the bearings; these could obviously be got over by mounting the inductor direct on the shaft of a steam turbine. A larger inductor, say 10 to 15 centimeters diameter, could also probably be used with 200 teeth and a speed of 30,000 revolutions per minute to give 100,000 periods per second. Secondly, the lamination of the iron must be carried to a very high degree to prevent eddy current losses, and the armature coils must be fixed as near as possible to the very tips of the poles. Thirdly, with accurately spaced teeth on the inductor a large number of armature poles could be used.

To measure the frequency, a Young's speed-indicator was used geared down from the inductor-spindle by means of worm and wheel, having a ratio of 20:1. Although the spindle was constantly run at speeds of between 30,000 and 40,000 revolutions per minute, no trouble was experienced with this gear. As no steam turbine or other high speed motor was available, the alternator was at first driven by means of a 8-shaped belt-drive from a ½ horse-power direct-current motor fixed with its shaft vertical to a wooden framework. Two bicycle wheels 24½ inches in diameter were employed; the one being fixed direct to the motor shaft as the driving wheel, the other, which was carried in an ordinary front fork and hub with ball bearings, acting as a tension pulley to balance the pull of the alternator spindle. The pulleys on the alternator spindle were of steel, having a diameter of only 10 millimeters at the bottom of the grooves in them. The number of turns of the alternator spindle for each revolution of the motor was found experimentally to be 42.5.

The inductor type of alternator was chosen. The inductor, 6 centimeters in diameter, was built up of 53 disks cut out of ferrotype plate, the iron being about 0.007 inch thick, inclosed between two plates 0.019 inch thick, the whole clamped together on a tool-steel spindle. The inductor alone weighed about 200 grammes. As at first constructed, the edge of the inductor had 30 V-shaped notches cut in it so as to have 30 flat-topped teeth. Surrounding the inductor is a laminated soft-iron ring having two inwardly projecting poles; the clearance between these and the teeth of the inductor, which formed the air gap of the machine, being less than 0.1 millimeter. The ring itself is wound so that a direct current flowing round the winding tends to produce lines of force from one pole to the other through the inductor. The number of lines of force varies from a maximum when the teeth on the inductor are opposite the poles to a minimum when the poles are in front of spaces. This variation in the total number of lines of force produces alternating E. M. F.'s in any winding either on the pole-pieces or on the ring itself; the movement of the inductor through the distance between two consecutive teeth producing one complete period. One winding on the ring could serve to carry both the direct field-current which magnetizes the ring and the alternating current produced. In practice, owing to the great importance of any self induction in the alternate current circuit, it was found advisable at high frequencies to use separate windings for the two currents. The ring was therefore wound in three sections as follows: Two sections, each consisting of a single layer of 113 turns of No. 33 double cotton covered wire wound next the core on each side of the ring which could be connected in series or parallel, were used as the armature. The third section consisting of four layers wound on top of the above, having 430 turns on each side of the ring, the whole being permanently connected in series, was used as the field coil. In whatever way the windings are arranged or used, it is necessary to prevent the induced E. M. F.'s from sending alternate currents round the exciting circuit, outside the alternator, as these currents would tend to annul the changes in lines of force through the coils and so prevent any useful alternating current from being produced. To prevent this the exciting circuit contained a choking coil. With this arrangement, frequencies up to 18,000 per second could be obtained. Subsequently the inductor was replaced by inductors having 60 and 90 teeth, with which frequencies up to 50,000 per second were obtained. This high frequency being still hardly sufficient to settle the question of the resistance of the solid arc, some means for still further increasing it had to be devised. As the highest speed of the inductor was only 600 revolutions per second, whereas the limit at which it was considered safe to run the inductor, owing to considerations of bursting, was 10,000 revolutions per second, attempts were made to increase its speed, but these failed owing to the large power required seriously overloading the motor. Practically this large increase of power required was expended in overcoming air friction on the wheel. The motor and bicycle wheels were therefore replaced by two phosphor bronze disks driven from an 8 kilowatt motor by means of ¼ inch gut bands. In the figure of 8 drive with only one wheel acting as driver, the spindle cannot be relieved of all pressure due to the belt, if the tension wheel takes any considerable power to drive it. Both disks were therefore made drivers, each being separately belted to the motor. Any speed up to 5,000 revolutions per minute, or a rim velocity of 327 feet per second, might be employed, but owing to the excessive vibration, due to the disks not being perfectly balanced, 4,000 revolutions per minute, a rim velocity of 262 feet per second, was the highest speed at which they could be continually run.



A 120,000-PERIOD ALTERNATOR.

At these high speeds the centrifugal force of the belt introduced a serious difficulty, as it tended to lift the belt right out of contact with the small pulleys, so that the slip became excessive. Many different kinds of belts and ways of joining them were tried; of all these, the 3-16-inch diameter cotton cord joined with a long splice, gave the best results.

In spite of every care, all attempts to run the inductor at 1,000 revolutions per second failed, owing to the heating of the bearings; but on removing the inductor from the spindle, this latter could be run at 1,000 revolutions per second with comparative ease. This was evidently due to the axis of inertia of the inductor not coinciding with its mechanical axis; all attempts to adjust this failed. The simple conical bearings were found to give the best results.

Experiments were next started to see whether the efficiency of the alternator could not be increased so as to allow the small amount of power required for the experiments to be obtained with an inductor having more than 90 teeth. An inductor having 204 teeth was therefore constructed. By placing search-coils on different parts of the field ring it was found that the E. M. F.s induced were much larger in those coils placed near the poles than in those placed on any other parts of the ring, from which it seemed that the changes in the number of lines of force produced by the movement of the inductor were confined to the neighborhood of the pole-tips, probably due to the magnetic leakage and to the eddy current, set up in the laminations. Coils were therefore wound right on the pole-tips themselves. Using the coil on one pole-tip only, which consisted of 10 turns of No. 30 double cotton-covered wire, it was found that the output of the alternator was 10 times as great as could be obtained with the original armature winding on the ring it-

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

self. With this inductor and the coils on the pole tips, it was finally possible to obtain a R. M. S. current of 0.1 ampere at frequencies up to 120,000 periods per second. The maximum P. D. at 100,000 periods per second with 0.1 ampere flowing was 2 volts, and on open circuit 3.6 volts. As this output, though small, was ample for the purposes of the research, no attempt was made to further increase it.

THE ECONOMIC VALUE OF NEW GAME FOR ISLANDS.

By Judge D. W. Prowse, LL.D., St. Johns, N. F.

In the great natural history of our day, the "Voyage of the Beagle," Darwin describes in a most interesting way how Nature has provided the islands of the Pacific with their fauna and flora. Modern man is not contented with those slow old methods of Mother Nature; he designs to play the part of special Providence himself, and to provide by artificial means new birds, beasts, and plants, especially for islands.

The most remarkable of all these various experiments was the introduction of English trout into New Zealand. To carry alive 16,000 miles through the tropics such delicate things as trout eggs seemed impossible, but Frank Buckland and his fellow enthusiasts were not daunted by their first failures. They persevered, and finally succeeded. This small box of eggs has done more to make the beautiful island of the Antipodes attractive to tourists than even her famous hot springs, her labor laws, or her socialistic experiments. The trout are specially lusty, and have turned the island's barren streams into a veritable angler's paradise.

Another venture of this kind which had a similarly wonderful effect was the introduction, some thirty years ago, of the varying hare into Newfoundland. The Hon. Stephen Rendell procured about half a dozen of those animals from Nova Scotia, and to-day they are in prodigious numbers all over the island. Darwin says that in a general way insular types are inferior to the continental ones. In this colony the rule is quite the reverse. This poor little hare, which furnishes scanty food for the wandering Indians and the Hudson Bay Company's trappers all over the sub-Arctic region and the barren grounds, has become in our island large and plump.

Its introduction has been of enormous advantage to the Newfoundland fishermen, giving them abundance of splendid food and lucrative employment in the winter, catching them for market.

This varying hare (the blue hare of Scotland) is so prodigiously plentiful that it is often a drug in the local markets at twenty cents a pair. A story is told of an economical major of engineers (a bachelor). He used to declare that a hare roast was splendid, next day it could be jugged, and the remains made a splendid soup.

Many English naturalists have made the mistake of confusing this hare with *Lepus glacialis*, the Arctic or polar hare. They are quite distinct. The Arctic hare is much larger and different, both in color and in its habits. It is indigenous to Newfoundland. In summer it has a beautiful coat of silvery gray, turning into a dead chalk white in winter, with black spots on each ear. While the varying hare seldom weighs more than seven or nine pounds, his Arctic congener tips the scales at twelve and sometimes fifteen pounds. Two most interesting experiments are now being carried out in Newfoundland. One, the introduction of the elk, known all over America as the "moose," is actually in operation. Many years ago a pair were introduced. Unfortunately, the bull moose was either killed or died from an accident; the cow survived and was seen alive not long ago. There were rumors that she had mated with the native caribou, and that some extraordinary progeny of this union had been produced. Naturalists will view these stories with suspicion, and there is really no foundation for the rumor. Last year three more moose were procured and let loose. J. G. Millais, author of "The Mammalia of Great Britain and Ireland," suggested that they should be placed in the wooded region of the Gander River. Curiously enough it was in those extensive woodlands that they were found a few weeks ago. They were strong and fat and the bull had grown immensely. This success has encouraged the Newfoundland government to proceed with the experiment on a larger scale, until a herd of twenty is procured, fifteen cows and five bulls. They will be protected by law for at least ten years. The vast interior of Newfoundland (larger than Ireland) and wholly uninhabited, will form an ideal home for these splendid animals. As moose meat is the finest of venison, and the animal in its full growth stands higher than a horse and is as large as a bullock, besides being an attraction for sportsmen it will furnish abundant food for the people.

One more project which is warmly supported by our governor, Sir William MacGregor, and the premier, Sir R. Bond, is the introduction of the tame Lapland reindeer into Labrador and northeastern Newfoundland. This will be watched by the naturalists of the world with the keenest interest.

Sir William, who is a very able man, distinguished for the leading part he has taken in the study of tropical medicine, goes thoroughly into this subject in his report on Labrador.

At present in both Labrador and northeastern Newfoundland numbers of savage dogs are kept for winter sledge driving. Those beasts are so voracious that they have been known to kill and eat poor women and children. No domestic animals can be kept where they exist. They prevent the Newfoundlanders from rearing sheep. If their place could be taken by the tame Lapland reindeer the whole condition of the poor Eskimos and settlers on Labrador would be materially changed. Instead of fierce canines they would possess a domestic animal, good for food and warm clothing, and the best possible means of communication during winter, in those desolate Arctic regions.

All European and American naturalists are agreed that the wild caribou of Labrador, Newfoundland, Alaska, and the American Arctic regions is precisely the same animal as the Lapland reindeer, and feeds on the same food. Where the wild animal can live the domesticated reindeer can also exist.

As an illustration of the absolute practicability of this project, Sir William MacGregor gives the experience of the Americans in introducing the Lapland reindeer into Alaska. One point is of great importance—they stand the voyage well, and as they are in herds of thousands their first cost is very reasonable.

The Lapland reindeer, after centuries of training, is as tame and obedient to man as the horse or dog. It has been suggested that they might be crossed by the wild caribou, a larger and stronger animal. We think, however, that it would be wiser to keep to the domesticated; the wild strain would be sure to break out in the cross breeds.

In 1891 the question of the introduction of reindeer into Alaska was raised by Dr. Sheldon Jackson. The Eskimos were threatened with extinction from want of food. White men had driven away the game, or destroyed it, and had depleted the salmon fishery by netting the rivers. It was found that the residents of eastern Siberia derived their subsistence chiefly from the reindeer, even to a greater extent than do the Laps. It was therefore deemed desirable that the reindeer should be introduced for the use of the Alaskan Eskimos. Congress having refused to grant an appropriation for that purpose in 1891, $2,146 was raised by private subscription for the purchase of reindeer. With this sum 187 deer were brought from Siberia, with regular herdsmen, to whom a certain number of Alaskan Eskimos were apprenticed as herdsmen and teamsters. From 1892 to 1904, 1,280 deer were imported from eastern Siberia to Alaska, and in 1904 the total number of fawns surviving was 10,267. In the official report of the commissioner for education, published 1905, it is stated: "It is perfectly safe to predict, from the inspection of the annual per cent of increase, the doubling of the herd every three years." All the female deer are preserved. The males are used as food, or trained to harness. Allotments of fifty deer are made to those natives that underwent apprenticeship. Seven Lap families, on account of being more civilized than Siberians, were in 1894 employed to take charge of the Siberian deer in Alaska, and to teach the Eskimos. Between December 1, 1899, and May 31, 1900, the United States ran a mail by reindeer, under contract, three round trips from St. Michael, at about 63 deg. 30 min. N., across the Seward Peninsula to Kotzebue, which is inside of the Arctic Circle, about 66 deg. 50 min. N. Each round trip of 1,240 miles was successfully accomplished through an unbroken wilderness without a road or trail. Several relief expeditions to the far north have been successfully carried out by United States officers in Alaska by means of reindeer, when such expeditions would have been impossible by any other means. A contract has lately been entered into to carry a regular winter mail over the 650 miles from Kotzebue to Barrow, the most northerly point of Alaska, about 71 deg. 20 min. N. It is said that on these journeys, "when used in relays fifty miles apart, reindeer can transport the mails at the rate of two hundred miles a day."

That both Newfoundland and Labrador are well adapted for the reindeer is shown by the fact that the wild caribou thrive in both countries. Millais, the great naturalist, declares that the very superior quality of the Newfoundland caribou is owing to the splendid food he obtains in the insular moors and marshes.

In this matter we have the experience of the United States for our guide and can profit by their experience.

In 1898 the United States government imported from Lapland 538 head of choice reindeer trained to harness, 418 sleds, and 411 sets of harness, a few herding dogs, and 50 drivers, some of whom had families, making in all 113 emigrants. These Lapland deer were not for breeding purposes, but only for harness. More than half of them died of starvation after reaching Alaska, as moss had not been provided for them. From 1894 to 1903, Congress has appropriated no less than $158,000 for the introduction into Alaska of domestic reindeer from Siberia. It has been found that "with careful training the Eskimos make excellent herders." It is thought that in thirty-five years there may be 35,000,000 reindeer in Alaska, with an export of 500,000 carcasses a year. The deer purchased in Siberia from the Chunchus cost $4, from the Tunguse $7.50 a head. It is stated by Mr. Gilbert H. Grosvenor that "the tame reindeer of Siberia was practically the same animal as the wild caribou of Alaska, changed by being domesticated for centuries." This corresponds with the general view of English zoologists, that there is but a single species of reindeer, but presenting local peculiarities. It appears that the Alaskan deer is not equal to the Lapland deer in strength or speed. A pair of the latter can pull a load of 500 or 700 pounds at the rate of thirty-five miles a day, and keep that up for weeks at a time. Mr. Armstrong states that a single deer can draw 600 pounds on a sled thirty, fifty, and even ninety miles a day. It is said the Lapland deer can in point of speed do 150 to 200 miles a day, and sometimes twenty to twenty-five miles down hill an hour. The Alaskan reindeer express has been driven at the rate of ninety-five miles a day. Reindeer can travel as well at night as in daylight. In Siberia a caravan of 160 sleds is managed by ten men. In summer a reindeer can carry as a fair load a pack of 150 pounds. A good deer can easily carry a fair-sized man.

The experiment of transporting the Lapland reindeer to Labrador will be watched with great interest all over the world.

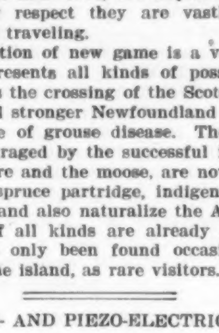
If successful (and there is no reason why it should not be so), it will help to solve one of the problems of Arctic exploration. As the wild caribou at the present time extends as high as 80 deg. north latitude, where the wild animal finds food, the Lapland deer can also live. In every respect they are vastly superior to dogs for Arctic traveling.

The introduction of new game is a very interesting subject, and presents all kinds of possibilities, such, for instance, as the crossing of the Scotch grouse with the hardier and stronger Newfoundland willow grouse, as a preventive of grouse disease. The colonial government, encouraged by the successful introduction of the varying hare and the moose, are now proposing to introduce the spruce partridge, indigenous in Canada and Labrador, and also naturalize the American woodcock. Snipe of all kinds are already numerous, but woodcock have only been found occasionally on the west coast of the island, as rare visitors.

PYRO- AND PIEZO-ELECTRICITY.

Though the phenomena of pyro- and piezo-electricity have been known for a long time, this knowledge has hitherto been confined to a very small circle. The results of recent investigations have, however, placed

Antilogous End.



Analogous End.

Fig. 1.—HEMIMORPHIC CRYSTAL OF TOURMALINE.

our knowledge of this department of electrical science on a solid basis, and some information on the subject may therefore be of interest to our readers.

Even in ancient times frequent mention was made, among others by Theophrastus and Diocles, of a certain very hard stone, which was used for seals and which possessed the property of attracting straw and other substances. And during the middle ages and up to the commencement of the modern era, the attention of Dutch travelers in India and Ceylon was directed to a stone possessing the same property and called "tournamal" or "trip" by the natives. As the crystal, when heated, attracted ashes, it was called "Aschentrecker" in Holland. It is now known under the French name "tourmaline."

The electrical nature of the observed power of attraction was first discovered by Æpinus in 1756. This remarkable property was then studied by a number of investigators, and many other crystals were gradually

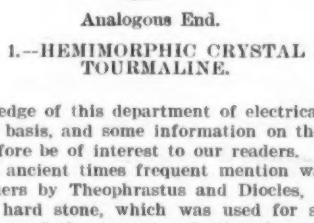


Fig. 2.

discovered which exhibited the phenomenon of electrical polarization when subjected to variations of temperature or, as was afterward observed, of pressure. Most of the investigations were qualitative only. But during the last decade exact quantitative experiments have been successfully made which, though confined for the most part to tourmaline and quartz, have yet permitted the formulation of laws, the calculation of constants, and the establishment of a very serviceable theory. The work done in this field by Hankel, Hallwachs, Thomson, I. and P. Curie, Gaugain, and Röntgen among many others should be mentioned, and special credit is due to Riecke and Voigt, who have obtained results of the greatest value both in measurements, and in the development of the theory.

Having briefly glanced at the history of pyro-electricity, we will now turn our attention to the phenomena.

Tourmaline, on which most of the experiments have been made, is a hemi-morphic crystal, i. e., a crystal having the two ends modified with unlike planes, as may easily be seen on reference to Diagram 1.

If one of these crystals is heated at a constant temperature for some time and then allowed to cool, the ends are seen to be electrically excited, the so-called "antilogous" end being positively, and the "analogous" end negatively electrified. This phenomenon is well shown in Kundt's experiment, which consists in blowing a mixture of powdered red lead and sulphur on the

crystal through a fine muslin sieve by means of a small pair of bellows. The sulphur, negatively electrified by friction, adheres to the antilogous end and gives it a yellow color, while the positively electrified red lead collects on the analogous end and colors it red. This experiment clearly shows the distribution of electricity on the crystal.

If the tourmaline is now allowed to remain for a time in the open air, it gradually assumes the temperature of the surrounding atmosphere and loses its electrical polarity. If it is then again heated, it will be found on trial, though for certain reasons not quite so clearly, that the previous phenomena are reversed: the antilogous end is now red and the analogous end yellow, indicating that they are respectively negatively and positively electrified.

Now let the crystal be removed from the heating apparatus. At first no electrical properties are visible, but after a time electrical polarization again appears, and in the same manner as in the first stage of the experiment.

This experiment shows therefore that variations of temperature give rise to the phenomena of electrical polarization in the tourmaline, and that the poles change places according as the crystal is heated or allowed to cool.

If a tourmaline crystal is broken into fragments, each fragment when excited will have two opposite electric poles like the portions of a broken steel magnet.

The next step is to combine the action of several tourmaline crystals. This can be done in two ways. We can either connect the crystals, or fragments of them, in a series, in such a manner that the antilogous end of one crystal comes in contact with the analogous end of the crystal next to it, an analogous and an antilogous end remaining at each extremity of the series, or the crystals may be connected in multiple, all the analogous ends being joined together and likewise all the antilogous ends. If this is done, it will be found that the first connection (Fig. 2) possesses no higher electrical polarization than a single crystal, but that in the second connection we get the total actions or current strength of the several crystals. Now as every crystal may be conceived to consist of a number of parts lying in parallel rows, it is evident that the intensity of the electrical polarization of a tourmaline is independent of its length, but that the current strength or action is directly proportional to the cross-section.

We have hitherto considered only the electrical phenomena of tourmaline excited by variations of temperature (pyro-electricity). Similar phenomena occur if the crystal is compressed or stretched in the direction of the axis of symmetry. To investigate these piezo-electrical phenomena as they are called, a prism, two planes of which must be perpendicular to the principal axis, is cut out of a crystal. These two planes are covered with tin-foil and their charges measured by an electrometer, the crystal itself being compressed or elongated along the principal axis.

When compressed, the tourmaline behaves in exactly the same manner as when allowed to cool after being heated; i. e. the originally antilogous end becomes positively, the analogous end negatively electrified; when expanded, and this expansion occurs naturally after pressure owing to the elasticity of the crystal, the phenomena of heat appear.

It is well known that heated bodies expand and that cooling bodies contract. It was natural therefore to conclude that the electrical condition of the crystal was caused solely by the displacement of the molecules resulting from the alteration in volume, and that therefore pyro- and piezo-electricity are in reality the same, the molecular displacement being caused in the one case by heat, and in the other by mechanical means. The truth of this assumption has been completely proved. For it has been ascertained by actual measurement that the quantities of electricity resulting from expansions corresponding to definite quantities of heat are nearly the same as those obtained from equivalent mechanical extension. The results in the latter case are certainly somewhat smaller. But that may be due to the fact that every mechanical expansion is accompanied by a loss, and every compression by a gain of heat. The purely piezo-electrical actions are thus, if we may avail ourselves of the original manner of regarding the matter to make ourselves more intelligible to our readers, always subject to a slight loss from simultaneous but opposite pyro-electrical actions. Whenever the volumes of two bodies are equally expanded, in the one case by mechanical means, in the other by heat, there is always a slight difference of molecular arrangement, due to difference of temperature.

We cannot here enter upon a consideration of the investigations by which we are enabled accurately to measure quantities of electricity; these are in their nature of very great difficulty, as are the laws which determine the dependence of the quantity of electricity on the specific qualities of the crystal and on external influences, but we will devote a few lines to an explanation of the theory.

According to Thomson and Riecke, tourmaline is a permanently electrified substance, like a steel magnet. This is the principal point to notice. Every molecule has its own electrical poles, all the molecules lie regularly arranged in the crystal, so that the tourmaline under ordinary circumstances should display electrical charges at the ends. But in consequence of deposited moisture, etc., the surface of the crystal, like the surrounding atmosphere, is not completely insulated; a surface layer of opposed electricity is formed, which neutralizes the electricity originally existing in the crystal. But if internal molecular displacements are produced by pressure or heat, the electricity in the planes at the ends of the crystal is altered in quantity, so that the surface electricity no longer balances it, and electrical phenomena appear at the ends. This has been shown experimentally by Riecke. The latter placed a pyro-electrical tourmaline under the receiver of an air-pump and suspended it in dry rarefied air; the crystal for a long time exhibited electrical phenomena although the interchange of temperature between the crystal and the surrounding space was very quickly effected.

All the results obtained by experiments on tourmaline hold good, with certain limitations, for most crystals. It is not necessary for electrification that the crystal should be hemimorphic; electricity can be excited in non-conducting crystals of all systems with dissimilar axes, and under certain conditions even in crystals of the regular systems. There is reason for believing that pyro- and piezo-electrical phenomena are much more common and play a much more frequent part in all natural processes than we have hitherto been aware of, for the number of substances having a crystalline structure is very great.—From the German of Max Dieckmann in Prometheus.

SCIENCE NOTES.

A curious effect of the recent volcanic and seismic disturbances has recently been brought to notice by the discovery in a jelly form of the mineral known as man-jack, washed up by the waves at Bathsheba off the northern coast of Barbados. It is believed that this substance has been discharged by volcanic agency through one of the fissures in the bed of the Caribbean Sea, of which deposits the Barbados man-jack beds are evidently ramifications. The discovery affords interesting testimony to the intensity of the volcanic heat, since extreme heat is required to convert the man-jack into jelly consistency.

At a recent congress of the French Academy of Sciences, the Prince of Monaco exhibited a newly-designed instrument intended for deep-sea research, which instrument he is utilizing in connection with his marine biological investigations. The device consists of an ingenously contrived glass vessel, which can be safely let down to the lowest known depths, the sounding wire with which it is connected at present being 18,000 feet in length. When the requisite depth has been attained, the water present at that level is admitted into the receptacle, and remains a pure, uncontaminated specimen, since no further water can enter while the vessel is being hauled through the upper levels to the surface.

The tomb of a young girl of the Gallo-Roman period has been brought to light at Nimes, and has been deposited in the local museum. The discovery, which is in a remarkable state of preservation, was made close to the ancient Domitian road built by the Romans. The grave contained a magnificent alabaster vase of Oriental production containing the girl's ashes, together with a casket filled with jewels, a gold necklace, a cameo ring representing Eros the god of love, together with a fine amber mirror, and a number of toilet articles which were used in those days by wealthy persons. A large variety of bronze utensils of the period were also unearthed in the tomb.

When isolated, or at least when outside of the cell, many enzymes are most active at temperatures far above those which may be maintained within the living cell. An explanation of this fact is difficult. Comparative studies of their reactions to light, heat, toxic agents and other stimuli should be made. In the penetration of parasites, cellulose-dissolving ferments are important, but further information is needed before it can be said that the presence or absence of such enzymes to any great extent affects the resistance of certain varieties and species to fungus attacks. It has been stated that the resistance of plants to fungus attacks is due largely to the presence of certain enzymes or toxalbumens present in the cells of the host; and by others it has been suggested that susceptibility is frequently a special property due to the presence of certain oxidases, which are regulated by external conditions.

The general phenomenon of chemotaxy, or chemotropism, demands searching investigation in view of the recent work of Jennings on flagellates, that of Newcombe on root responses, and other studies on the fungi. There is much to be done in determining the effects of heat and cold upon special processes, in a study of the relations of temperatures to other conditions of the environment, and in showing the limitations of accommodation phenomena. In the latter study, moreover, the effects of accommodation upon the general constitution of the organism should be followed. Stimulation at high or low temperatures merely expresses an intensified or modified irritability. It may be observed in this place that death at the supramaximal or subminimal may be due to changes of a very definite nature; but as Vines has indicated, this means very little. To say that death at the supramaximal is due to the coagulation of an albuminoid as suggested by Kuehne is insufficient. For the immediate effect upon the protoplasm of this high temperature must also be of consequence. The external conditions of temperature or the effects of a modification of conditions are more or less readily determinable; but it has not been possible to follow the internal changes which result. It may be noted that the freezing point of a plant is lower than that of the expressed sap; yet of course the freezing point is not necessarily a valuable indicator of injury. The effects of temperature upon reproduction will be treated of later.

ELECTRICAL NOTES.

Use of Electricity in the German Navy.—The man-of-war "Preussen," which was launched at Stettin somewhat over a year ago, is to be attached to the Baltic squadron. It is 438 feet in length, of 13,200 tons displacement, and is provided with engines of 16,000 horse-power. Its speed is 18 knots. This vessel is lighted with electricity from the bridge throughout. It is provided with four large searchlights, or projectors, each of more than 7,000,000 candle-power. All the operations on board, the transport of munitions, the loading of ordnance, the rotation of turrets, the launching of boats, etc., are accomplished by means of electric motors. All the apparatus serving for the communication of orders and the transmission of signals is operated electrically.

A large number of special conditions may enter into the determination of the size of the motor required for any particular machine tool, the class of work it is to be restricted to, the grade of material, whether cuts, if heavy, will be of short duration, etc., so that it is rather difficult to make a statement that will fit all cases, but the writer would suggest the following for determining size of motor for average conditions—assume a cutting speed of fifty to seventy feet a minute for soft steels, estimate the maximum size of cut that will likely be required for any time longer than thirty minutes, transfer this into pounds of metal removed per minute and multiply by 2.7, then select a motor which will develop this power throughout the range of speed desired.

A comparison of the old process of immersion in molten zinc with the electrolytic process of I. Szirmay was discussed by H. I. White in the Iron and Steel Magazine. Roofing sheets, tubing, and iron and steel wire were coated with zinc by the two processes and then tested mechanically and chemically. The mechanical tests included bending and folding, winding spirally, stretching, cutting lengthwise to show interior coating (in the case of tubes), and hammering. The chemical test consisted in submitting the galvanized articles in an atmosphere containing 15 per cent CO_2 and 12 per cent SO_2. It is considered that the tests prove in a convincing manner that steel and iron coated by the Szirmay process are superior to those galvanized by the hot process in their resistance to mechanical as well as to atmospheric action.

A method based upon the electrolysis of carnallite (magnesium potassium chloride) in the fused state, with separation and recovery of the chlorine liberated at the anode; and of the impurities and insoluble portions of the raw carnallite, not acted upon by the current, is described by E. Haag in Elektrochem. Zeitschrift. The apparatus comprises an upper part for receiving and melting the raw carnallite, a central electrolyzing part provided with perforated carbon electrodes, in which the actual electrolysis occurs, and a lower portion in which the molten magnesium and insoluble impurities are received and separated. The chlorine gas rises through the perforated electrode and passes away by a funnel-shaped hood which covers the upper part of the apparatus. The carnallite and the magnesium which is separated from it are kept in the molten state by resistance heating, and the various portions of the apparatus are maintained gas-tight by seals formed of these molten materials. The whole apparatus is inclosed in an air chamber to reduce heat losses by radiation. The magnesium flows away by a side opening in the lower part of the apparatus, and the impurities and insoluble portions of the carnallite by another. The process is, therefore, continuous, and heat may be applied externally if so desired, to assist in maintaining the required temperature.

The regions in France in which hydraulic power is now utilized to a large extent for operating electric plants are in the first place the Alpine country lying between Lyons and the Swiss frontier, which has Grenoble for a center, and second, the Maritime Alps lying near the Mediterranean and giving a large amount of power to Nice and the adjoining towns. In both these regions the use of power is developing to a large extent, and especially in the Grenoble region we find it employed not only in the large factories, but also in the towns and villages in the small industries of various kinds. Among the most important hydraulic plants of this region we may mention the turbine plant erected at Champ, on the Drac River about eight miles from Grenoble. It is controlled by a large company, the Fure et Morge. This plant is of interest from the new method of hydraulic construction and also from the fact that a very high tension is used on the line, or 26,000 volts, making it one of the highest in Europe. At present there are running five turbine-and-dynamo units. These consist of horizontal shaft wheels of French make connected to Swiss alternators of the Brown-Boveri pattern. A total of some 8,000 horse-power is given by the station at present. The plant is laid out on the three-phase system, and the alternators furnish a tension of 3,000 volts. Five large transformers raise this to 26,000 volts for the overhead line. The river spreads out over a wide bed, and has a variable flow, which made the hydraulic work difficult. A dam is built clear across the bed of the river, but it is of the submersible form and consists of a permanent wall of masonry. At one end is a side canal which opens from the dam. The total length of the dam is 420 feet, with 50 feet width at the base and 10 to 20 feet height. The main canal, 2,000 feet long, leads to the penstocks. At present but one of

these is used, and its total length is 15,000 feet. Part of it is built of armed cement, using a series of hoops as a skeleton frame. A net fall of 120 feet is obtained, with a flow of 20 cubic yards per second. The station at Champ may be reckoned among the largest in France. It sends out a number of overhead lines which run through many towns and villages, giving current over a wide extent of country.

ENGINEERING NOTES.

The modern locomotive question is principally a question of boiler. The great increase in the size of boilers, and in the pressures carried, which has taken place during the past few years has necessitated the reconsideration of the principles of design which have been worked out and settled during many years' experience with comparatively small boilers carrying low pressures. The higher temperatures incidental to the higher pressures have required the provision of much more liberal water spaces and better provision for circulation. Locomotive engineers have now apparently settled down to the use of one of two types of boiler for very large engines—the wide fire-box extending over the frames and wheels, and the long narrow box sloping up over the axles behind the main drivers.

It must not be assumed that the land which is capable of dealing with the largest quantities of sewage effects the greatest amount of purification. The reverse is frequently the case. As in the case of a bacteria bed the features tending toward quality of effluent are largely opposed to those enabling a large volume to be dealt with on a given area. The analogy between the proper working of a bacterial system and the performance of the same work upon land will be found complete when followed through its various stages. Any attempt to force unduly large volumes of sewage through bacteria beds without affording the necessary periods of rest for the proper development of the purifying bacteria and the full digestion of the organic matter carried on to the beds in the sewage produces choking and failure to deliver a purified effluent in the same way that like causes inhibit success on land.

Contrary to a common assumption, experiments show that when forced to maximum power, the large boilers delivered as much steam per unit area of heating surface as the small ones. At maximum power, a majority of the boilers tested, delivered 12 pounds (or more) of steam per square foot of heating surface per hour; two delivered more than 14 pounds, and one, the second in point of size, delivered 16.3 pounds. These values expressed in terms of boiler horse-power per square foot of heating surface are 0.34, 0.40 and 0.47, respectively. The two boilers holding the first and second place with respect to weight of steam delivered per square foot of heating surface are those of passenger locomotives. The quality of steam delivered by the boilers of locomotives under constant conditions of operation is high, varying somewhat with different locomotives and with changes in the amount of power developed, between the limits of 98.3 per cent and 99.0 per cent.

It was at first thought that while sewages mainly of a domestic character could be bacterially purified, the successful application of the system to the sewage of a manufacturing center was a doubtful proceeding. To set this point at rest was one of the leading objects of the experiments carried out for the city of Manchester during the year 1898-9 by the Manchester experts, who reported (in October, 1899):

"That the bacterial system is the system best adapted for the purification of the sewage of Manchester, and that any doubts which may have arisen in the first instance as to its suitability, owing to the presence in Manchester sewage of much manufacturing refuse, have, through the convincing results of our experimental inquiry, been entirely banished. . . . The results obtained have altogether exceeded our expectations as to the possibility of purifying a manufacturing sewage, inasmuch as it was previously a matter of common belief that in such a liquid only a most insignificant amount of nitrification could be induced."

The results of operations in 1905 on the Pittsburg & Lake Erie and the Bessemer & Lake Erie roads are referred to by the Railroad Gazette as little short of marvelous. It says: "When two railroads are able to show average revenue trainload figures, one of 937, the other of 1,076 tons, it is remarkable enough; but when we learn that the average tonnage southbound on one of them is 1,406 tons per train, there is a chance to realize the immense economies of modern methods of handling heavy tonnage. The Bessemer & Lake Erie, which shows this exceptional figure, is largely an ore-carrying road, ore furnishing nearly six of the 9,500,000 total tonnage. As part of the machinery developed by the United States Steel Corporation for transferring Lake Superior iron ores to the Pennsylvania mills, the road shares in the tremendous economies which have been brought about by modern methods of handling and transportation. On the Pittsburg & Lake Erie, on the other hand, coal and coke furnish over 14 of the nearly 25 million tons, ores amounting to not quite 3,500,000 tons. A large tonnage of manufactured iron and steel products in addition helps to make the road nearly twice as heavy an earner on a mileage basis as the Philadelphia & Reading, which has the next largest gross earnings per mile of any American railroad. The fact that the Vanderbilt road is operated at 43.4 per cent of gross for expenses and the Steel Corporation's line at 48.99 per cent goes to show how profitable railroad operation can be when sufficient traffic is available."

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